AGRICULTURAL ENGINEERING

MARCH • 1952

The Development of the Brush-Type Cotton Harvester *W. J. Oates, R. H. Witt, et al*

The Practical Application of Time-Travel Studies on Dairy Farms *Thayer Cleaver*

Safety in the Operation of the Mechanical Corn Picker *Charles J. Scranton*

Results of Studies of Heat and Moisture Loss from Swine *T. E. Bond, C. F. Kelly, et al*

Results of Hydromechanical Studies of Soil Erosion Processes *Louis J. Goodman*

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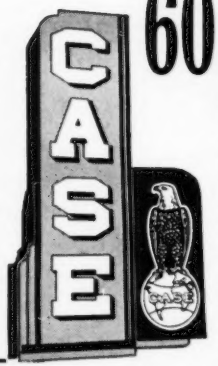

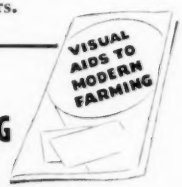

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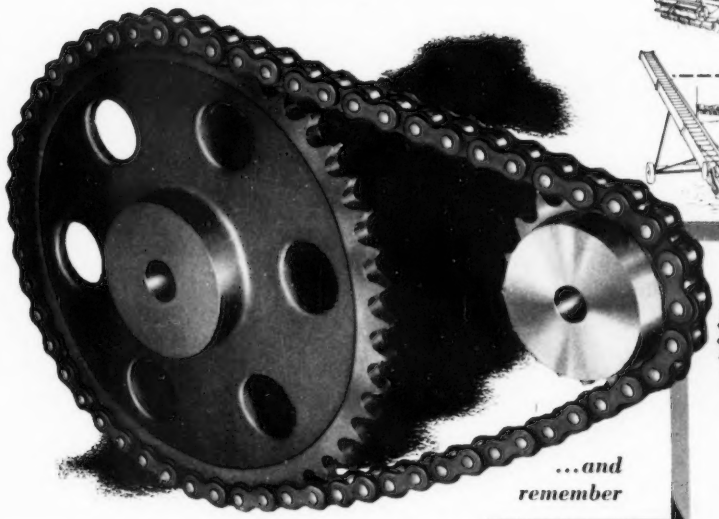

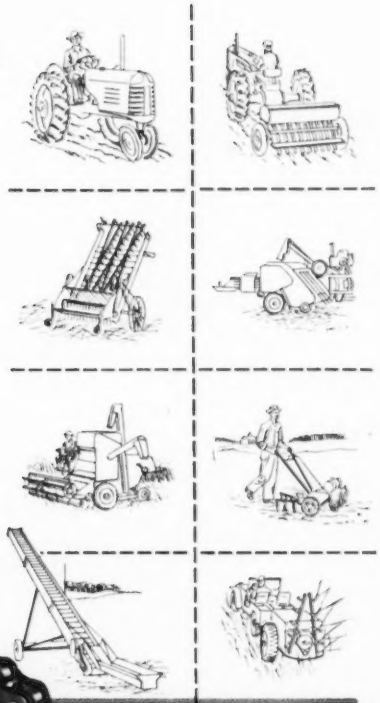

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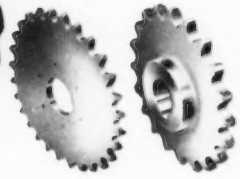

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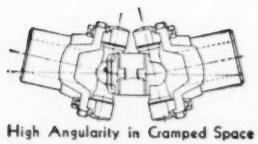

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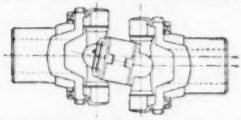

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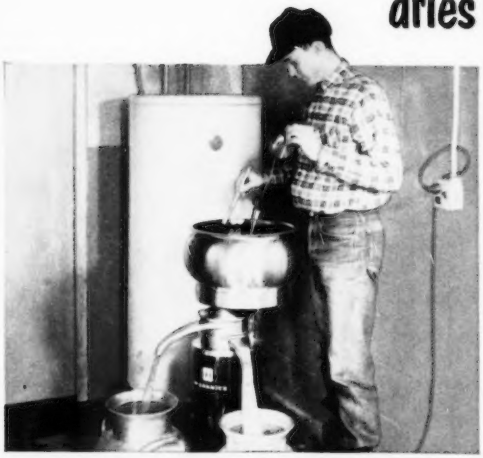

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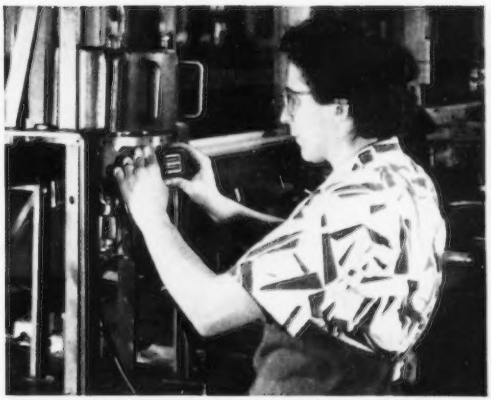

Constant speed direct drive gets more butterfat and increases the hourly capacity of the separator. That's why this IH inspector is using a tachometer to make sure the governor-actuated mercury switch turns the direct-drive motor on and off to maintain a uniform separating speed of 10,000 rpm. When the bowl is slowed to 7,000 rpm, water escape holes open automatically for power washing.

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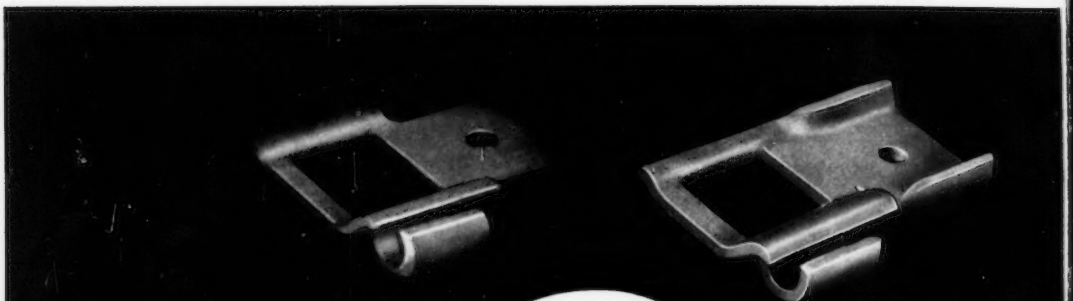

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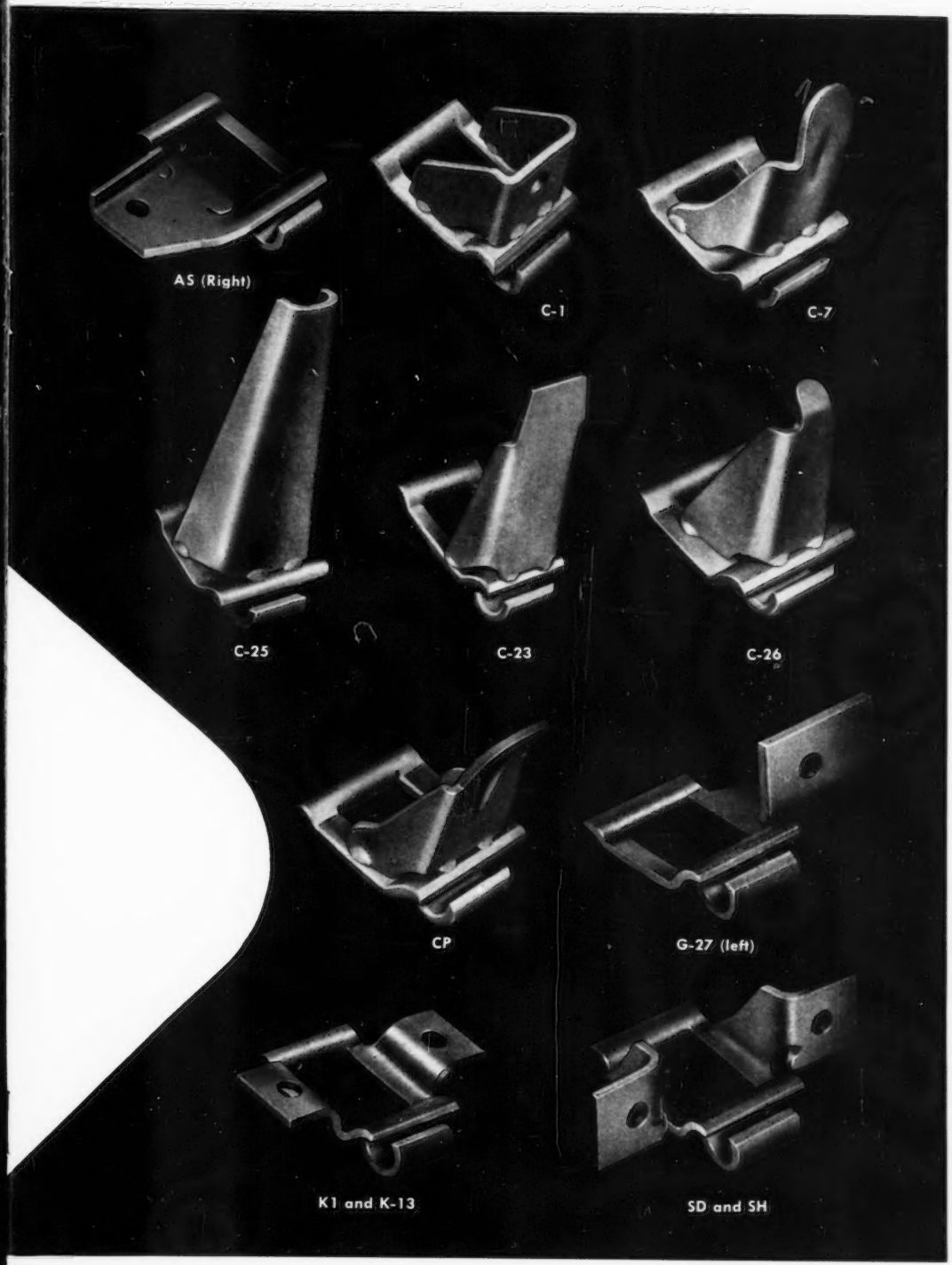
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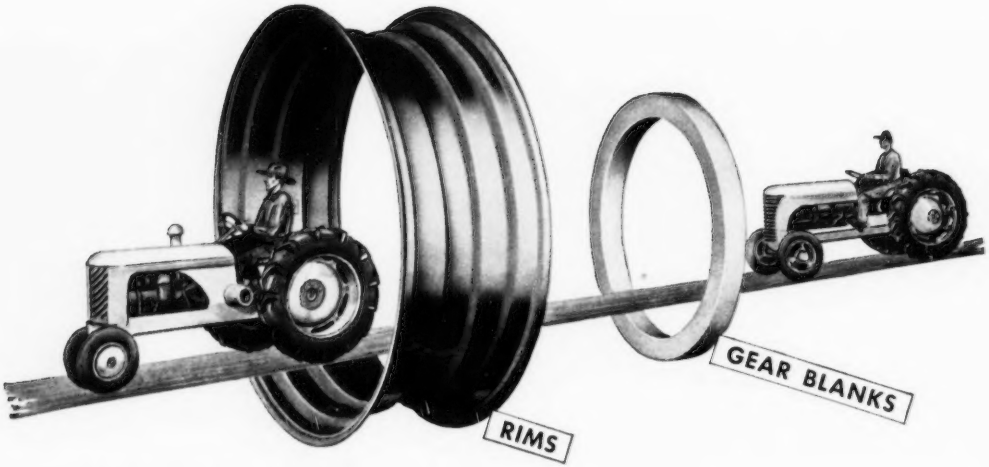

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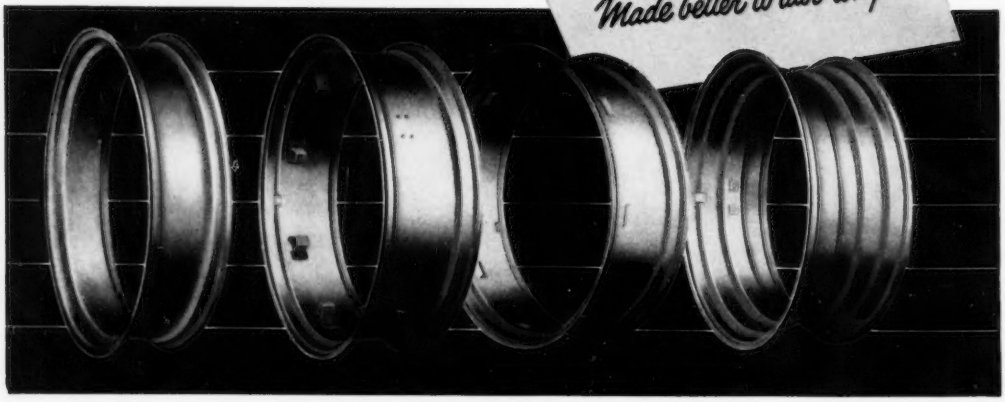

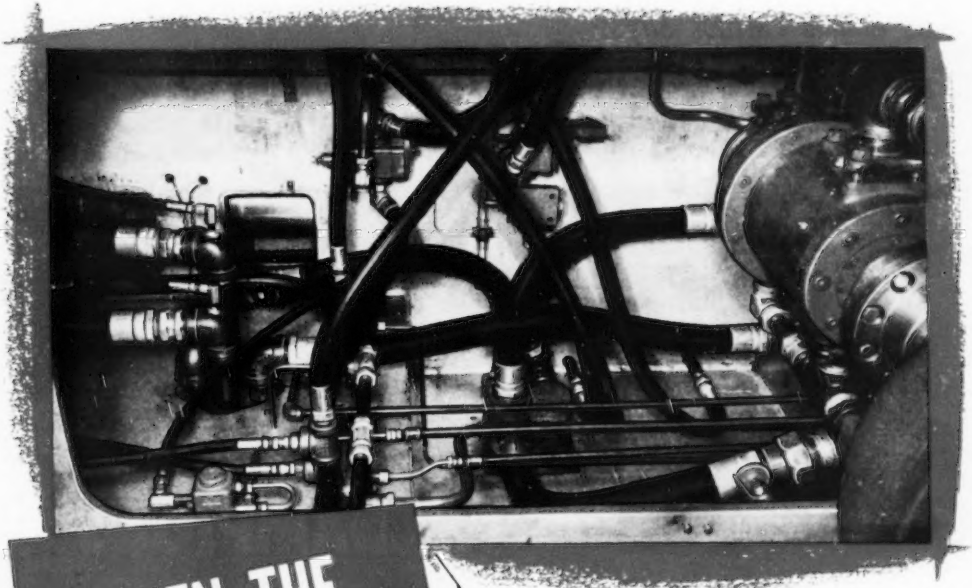

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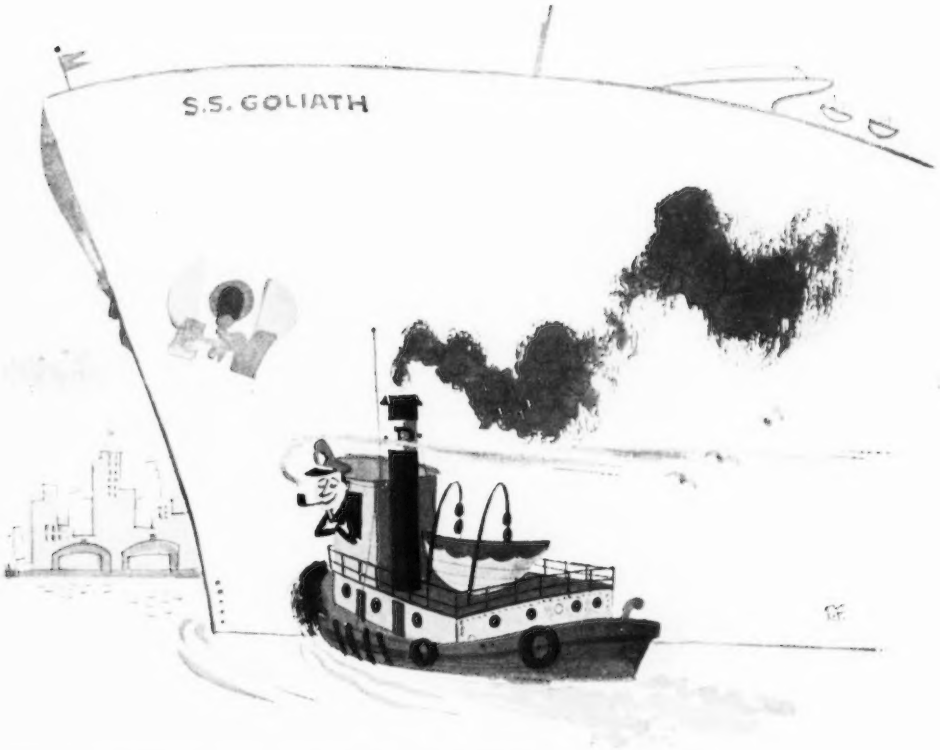

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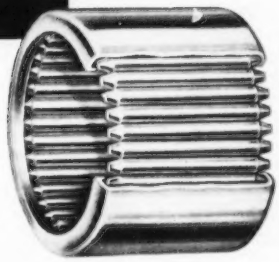

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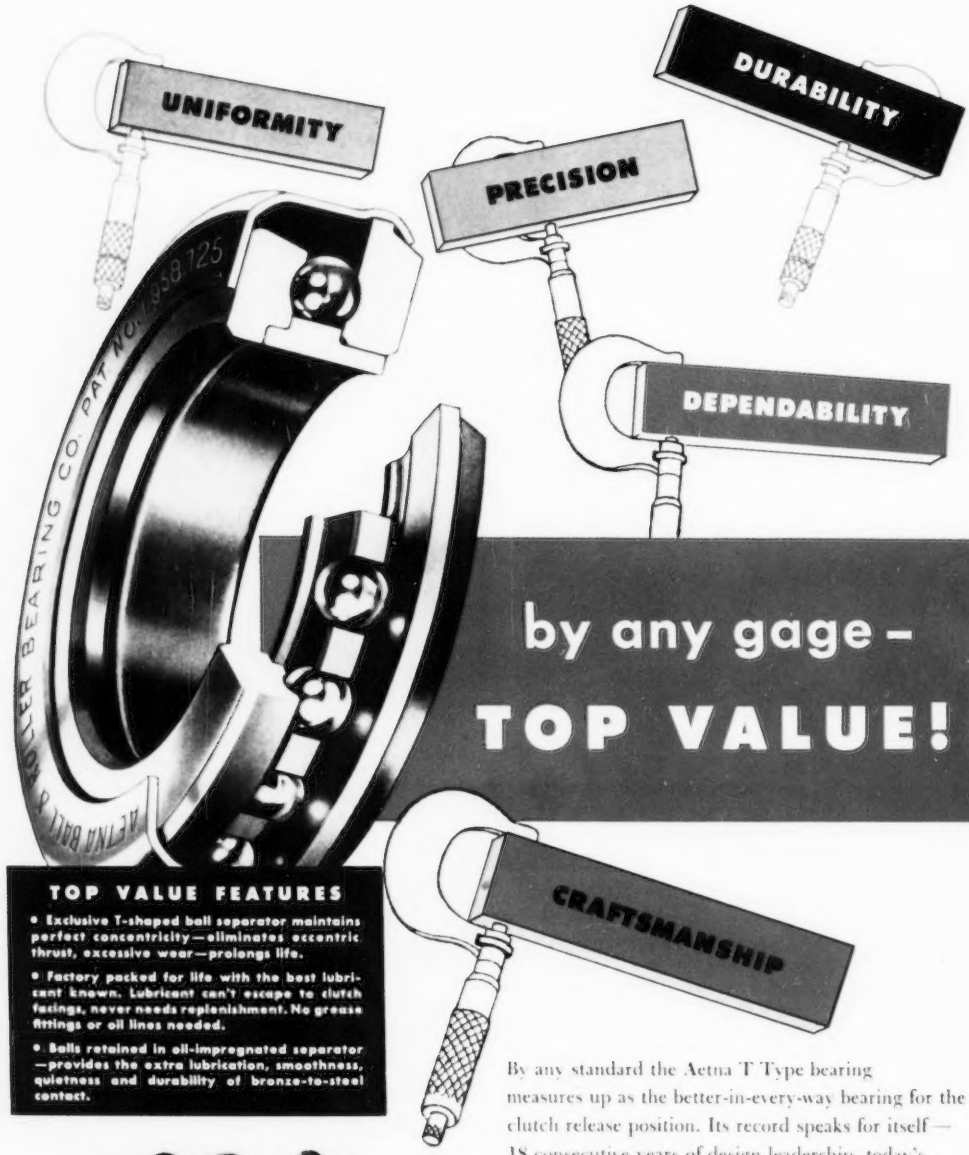

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This Massey-Harris Combine utilizes two Link-Belt Screw Conveyors—one back of the sickle bar and the second in the elevator. Other vital components built by Link-Belt for this M-H machine: Roller Chain Drives and Couplings and Steel Link-Belt.

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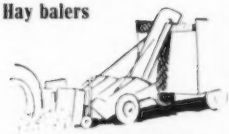
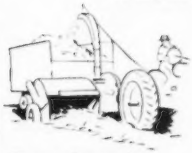
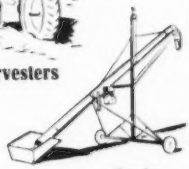


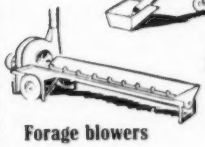
Cotton harvesters



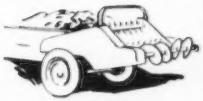
Forage harvesters



Grain loaders

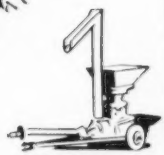


Forage blowers



Spreaders

Post hole diggers



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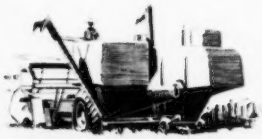

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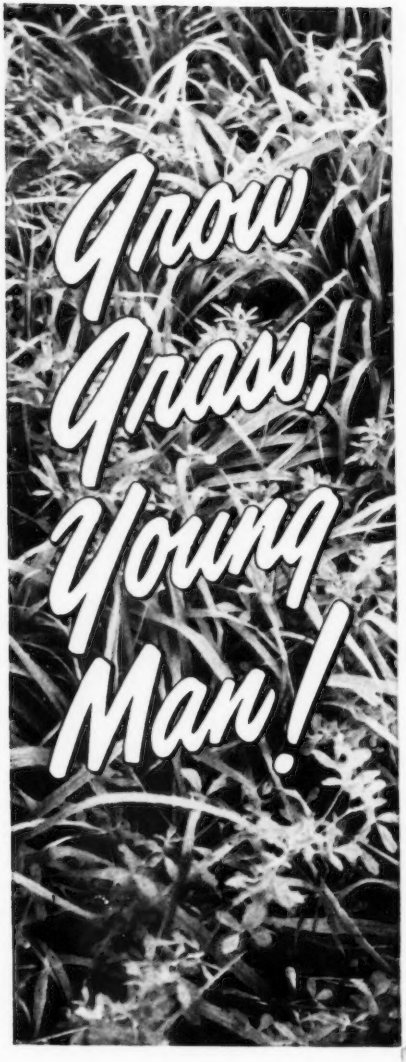


A hundred years ago, Horace Greeley popularized an idea: "Go West, young man, and grow up with the country!" If Greeley were alive today, he might well join the modern refrain: "Grow grass, improve the soil, and increase production."

Fitting naturally and logically into soil conservation farming, grass has become one of America's new frontiers. As a nation, we are suddenly aware that grasses and legumes are not only great soil holders but also great soil builders. And, thanks in part to better grass management, we have suddenly realized that grasses and legumes are money-makers, too.

So grass becomes a new frontier—one with lots of room to grow. The U. S. Department of Agriculture reports that of about 1 billion acres now in grasslands, probably not more than 10 to 15 per cent is improved. Yet there is ample evidence that many of these acres could produce up to six times as much as they are now producing.

Thus, history repeats itself. A century ago pioneers were putting sod-busters to endless fields of waving prairie grasses. Today, farmers all over the country are rebuilding grasslands anew. Modern farm equipment makes the job easier, faster, better.

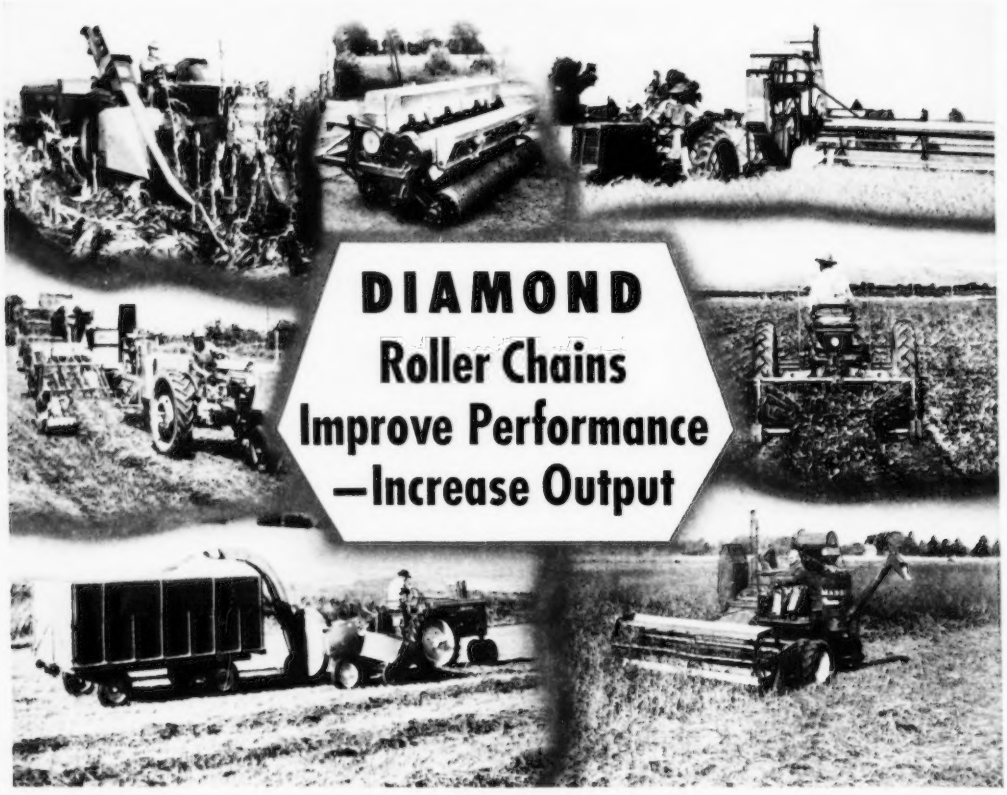
* * *

BELOW—On a Florida cattle ranch, grass *is put to work*. This tract was once covered with natural browse, rugged but unpalatable grasses, palmetto, briars, and bushes. The scrub was eradicated, the field fertilized and established in highly-productive pasture grasses and legumes. When the picture, below, was made last year, this field was growing a good crop of grass—but not good enough. The owners knew it was time to renovate—a speedy, easy task with modern equipment.

JOHN DEERE

Moline, Illinois

On Leading Makes of Agricultural Machinery



Highly efficient machinery is no longer restricted to the modern manufacturing plant — smooth-operating, long-life high speed Diamond Roller Chains have added dependability and output efficiency to mechanized power equipment that has put America far in the lead in agricultural production.

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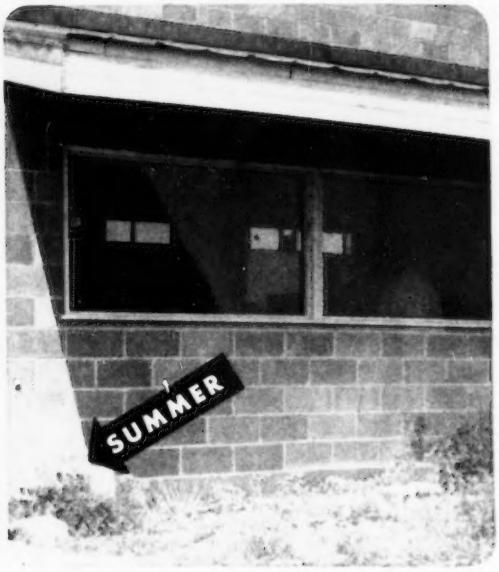

HOW TO CONTROL THE SUN
for winter warmth and summer coolness

Sunshine can do a lot to keep farm service buildings warmer and drier in winter. This is an important benefit in milkhouses, such as shown above, and in many buildings where improved conditions benefit the health and production of livestock and poultry.

You want sunlight in winter. But you don't want more sun heat in summer. This solar milkhouse shows how you can bring sunlight in *only* when you want it. See the shadow lines. Notice how the roof overhang shades the windows from summer sun, but lets sunshine stream through the windows in winter. This difference is possible because the sun is so much lower in the sky in winter.

There are several rules to follow in planning solar buildings:

1. Use large windows, facing south, to flood the interior with warm sunshine in winter from sunrise to sunset. For maximum daylight, use large panes, free of cross-members.
2. Glaze windows with *Thermopane** insulating glass. *Thermopane* helps keep buildings warmer and drier in winter, and cooler in summer. It reduces condensation on windows and thus helps keep down maintenance costs.
3. Use a roof overhang or other suitable shading device. It should be designed to meet both requirements—summer shading and winter sunlighting. We have developed a Sun Angle Calculator with which you can determine proper size of shading devices for various latitudes. (Described below)

Thermopane is easily installed—in fixed or opening sash. Standard sizes are available in economical sheet glass, made especially for use in farm service buildings. *Thermopane* is sold by glass and building supply distributors and dealers.

Sun Angle Calculator . . . Libbey-Owens-Ford and Aeronautical Services, Inc., have together developed a device which enables you to answer problems in sun control. It is simple to use—works for latitudes 24° to 52° North—for walls facing any direction. You can figure depth of sun penetration into a building. Also estimate solar heat gain. Available at $9.50. Since this is less than cost, be sure your letterhead stating your profession accompanies your order and check.

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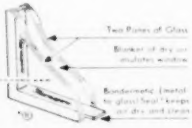

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"Wide-Flow" Feed

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Those are the tough specifications Allis-Chalmers set out to meet in building harvesting machinery for the family farm.

One basic design principle back of this company's success is the handling of grain, hay and forage crops in a wide, thin flow.

Dotted-line arrows show the wide feeding throat of the ALL-CROP Harvester, the ROTO-BALER, and the FORAGE HARVESTER. All three handle the crop in a wide, free-and-easy flow . . . without choking or bottlenecking.

You see the result in cleaner grains and seeds, more thoroughly threshed. In higher quality forage, cleaner cut without bruising or shredding. In leafier hay, rolled up layer on layer in a new, weather-resistant bale.

"Wide-flow" feed steps up capacity tremendously . . . saves power, fuel, and crop losses. It has helped greatly to bring all the advantages of home-owned and home-operated harvesters to the family farm.

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EDITORIAL

Double-Duty Information

IN LEARNING to think and work as an engineer, a student undertakes the well-known formidable task of making his mind a large, well-stocked, orderly informational toolroom. At the same time, he is under pressure to acquire special skills in the use of those tools of the mind, to develop some degree of objective outlook on the application of science to the service of man, and to cultivate some concept of his future responsibilities as a professional man.

Conceding that he cannot in a few short years achieve the ultimate in information, skill, and wisdom, his problem and that of his teachers becomes one of selecting, evaluating, and combining educational experience within his individual capacity, as a foundation for effective further development and work as an engineer. Keeping his informational toolroom uncluttered may be as important as getting it adequately stocked.

One characteristic engineering approach to this problem of educational efficiency is that of making certain technical information perform double duty. Engineering principles can often be illustrated with specific applications, data, and problems in the student's chosen field of specialization. Combinations of general and specific knowledge which may prove most useful following graduation can be primary aids to the development of interest, understanding, and engineering skills.

It appears to us that this is the sound basic philosophy behind the Ferguson Foundation Series of agricultural engineering texts.

The second in this series, recently published, is "Tractors and Their Power Units," by Barger, Carleton, McKibben and Bainer. Like the first ("Farm Structures," by Barre and Sammet), it is an advanced text for students who have completed various prerequisite basic courses in engineering. It is intended to provide advanced instructional material better suited to their informational requirements than either a non-technical treatment of the subject, an advanced text illustrating many of the same principles with examples of applications in other fields of engineering, or a miscellany of references.

In references cited and credits to other authorities the text measures up to high engineering standards. Incidentally, one of the authors has especially credited AGRICULTURAL ENGINEERING and its contributors through the years with providing material exceptionally helpful in the preparation of this text. All concerned may take satisfaction in having had some small part in its development.

Without new recruits, the very philosophy of progress in any field tends to stagnate! The new texts with double-duty information should prove a material help to attract and hold the interest of the able young men necessary to prevent any stagnation of progress in agricultural engineering.

Causes of Carelessness

A RECENTLY reported survey of traffic accident cases indicates that many of the drivers responsible were emotionally disturbed before the accidents occurred.

In fact, in many cases the driver was downright sore at someone or some turn of events. He or she was driving mechanically with less than normal visual and auditory perception of traffic conditions, traffic signals, and warning signs. He did not realize that he was intoxicated with anger, as dangerously for driving purposes as though he had been bending his elbow at a roadside tavern.

Carelessness has long been recognized as one proximate cause of accidents on farms as well as on highways. In that sense it is little more than a blanket term to account for otherwise unaccountable human behavior.

Possibly we can now teach farmers to see through this screen and to anticipate carelessness and extra accident hazards whenever they or others may be below par in physical or mental alertness for any reason. In many cases potentially hazardous farm jobs can be postponed a few hours or days, or done by others until an individual returns to the normal mental and physical alertness necessary to handle the job with reasonable safety to himself and others.

Possibly some agricultural engineer can devise a simple sensory perception and reaction-time test by which a farmer could recheck his alertness frequently and on short notice. If so, safe minimum alertness levels for operating various types of farm machines within a range of operating conditions might be worked out and made known to farmers.

At any rate, recognition of causes of carelessness looks like a step toward increased farm safety. Relating those causes to physical hazards in the farm environment is a matter in which agricultural engineers might render a valuable service.

Kilowatts Working

NOW that kilowatts have been placed within reach of most farmers, a number of factors point to a period of intensive development of their potential usefulness.

Farmers are ready. Many have changed from the consumer-luxury viewpoint concerned with keeping the monthly bill as small as possible, toward the production-service viewpoint of actively looking for additional opportunities to show a high return on a high meter reading.

The well-known scarcity and high cost of dependable farm labor is more than a result of inflation or an otherwise transient condition. It is a matter of people raising their estimate of the value of human life, work time, capacity to produce, and capacity to enjoy the fruits of production.

In using the time of themselves, their families, and any help they may hire, farmers are in competition with the rest of the world for effective production of goods and services in strong demand at something more than the production cost. It is a competition which recognizes that diligent attention to labor and power use can generally result in some further lowering of production costs. It is a competition which is clarifying the economics of using electricity for easily controlled stationary electric power, light, and heat; and the economics of using human effort primarily for those planning, directive, manipulative and discretionary functions in which it still excels the economy and capacity of machines.

The electrical industry is ready. Getting kilowatts delivered to farms and used there effectively in quantity has taken the cooperation of large numbers of people with many different abilities, and filling a variety of positions. They have built a sound foundation of generating and distribution capacity and use equipment with which to put more kilowatts to work on farms.

Agricultural engineers are ready. Increasing numbers of agricultural engineers and their employers are recognizing the applicability of engineering technology to the further development of farm electric power use. They are recognizing physical factors subject to engineering manipulation and management for human purposes, in the source materials of farm production, the biological mechanisms of that production, the product results, the operations involved, the energy required, the variety of electrical effects applicable, the electrical, mechanical, and structural designs through which they may be applied.

One indication of the increasing extent to which agricultural engineers are ready, willing, and able to increase farm use of electricity is in the membership of the American Society of Agricultural Engineers. Of those who indicate primary interest in rural electrification, 65 per cent are new members since the beginning of 1946. It is providing opportunity for employment and professionally satisfying service utilizing their engineering training.

With this combination of forces behind rural electrification, farms in the near future may be expected to show to a greatly increasing extent the signs of "kilowatts working."

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A dual triumph, it tapped a power source *greater* than human muscle — to operate an implement *better* than the scythe.

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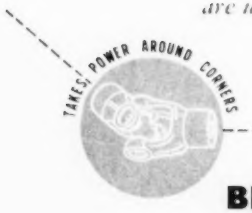
For farm implements, more Blood Brothers Universal Joints are used than all other makes combined.



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AGRICULTURAL ENGINEERING

VOL. 33 MARCH, 1952 NO. 3

The Development of a Brush-Type Cotton Harvester

By W. J. Oates, R. H. Witt, and W. S. Wood

MEMBER ASAE ASSOC. MEMBER ASAE

ONE great difficulty in developing a successful mechanical cotton harvester is that of building a machine versatile enough to harvest a crop that is so sensitive to varying conditions of climate and soil fertility and includes so many different varieties having highly diverse plant characteristics.

Cotton harvesters now available to farmers are of two basic types: the picking machine and the stripping machine. Pickers are adapted primarily to areas of high rainfall or locations where the crop is irrigated. In those areas, yields are usually high, the fibers long, bolls are of the open type, and vegetative growth is extensive. Strippers are most successful in the High Plains of Texas where plants are small and the fibers are rather short, hard bodied, and easy to clean.

The ¾ to 15/16-in cotton grown in Oklahoma can be classed as a type midway between "good picking" and "good stripping." It is representative of approximately one-half the acreage of the entire cotton belt.

Investigations of the mechanical characteristics of cotton harvesters and their effect on harvester efficiency have been under way at the Oklahoma Agricultural Experiment Station since 1947. These investigations included a detailed study of both the picker and stripper-type harvesting machines. By the end of the 1948 season it was evident that the stripping principle was best adapted to the conditions that exist in the subhumid plains of the Southwest; therefore, the work since that time has been devoted largely to improvement of the cotton stripper.

Principles of Stripper Operation. The stripping of cotton at present is accomplished by passing all parts of the plant between two or more fingers, two rolls, or one roll and some type of stripping bar. The forward motion of the machine applies a force in a plane perpendicular to the ground. These forces must be opposed by the root system of the plants.

Problems Encountered with Present Strippers. The presently available strippers do a satisfactory job of harvesting cotton in the area for which they are adapted. When they are used in areas other than the High Plains, a number of problems are encountered, some of which are as follows:

1. Stripping takes place after frost. Many of the plants have been killed, and limbs and stalks are brittle. Any aggressive action on the part of a machine breaks these limbs. They clog the machine, increase field losses, and make ginning more difficult. The final result is a lower quality fiber.

2. Stalks that are larger than average are wedged in the stripping mechanism. The applied forces become so great that the root system cannot resist and plants are pulled from the soil. This greatly impedes progress through the field and increases field losses.

3. The necessary openings between rolls or between the fingers allow loose locks to drop through and fall to the ground.

4. Losses when turning at the row ends are very great unless the machine is cleared before turning.

5. When yields are greater than ½ to ⅝ bale per acre, usually a helper must ride the trailer to keep the cotton moved to the rear.

An effort was made to increase the efficiency of strippers by using different rates and spacings for the plants, by varying the ratio of stripping-roll speed to ground speed, and by using specially selected varieties of cotton. These efforts resulted in no significant increase in efficiency. Therefore, a different principle or a different approach to the same old principle seemed desirable.

Careful study and analysis of the problem indicated that most of the preceding problems could be overcome by using brush stripping rolls and a pneumatic conveying system.

Principles of the Brush-Type Stripper. The distinguishing feature of the machine are the rolls, made by mounting strips of fiber bristles on a steel core (Fig. 1). The two brushes run parallel to each other and rotate in opposite directions. The cotton plant is pulled between these rolls in the same manner as in the conventional machine. The bristles remove the cotton boll from the plant but do not break the limbs. The large stalks move between the rolls with ease, as the bristles allow "automatic" adjustment for each size stalk. The close-running brushes do not allow loose locks to filter through.

Brush Characteristics. The bristles used for these stripping rolls must possess certain necessary characteristics in order to accomplish the harvesting. These characteristics are:

1. Must be self-cleaning.
2. Must not tangle the cotton fibers.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Power and Machinery Division. It is also presented as a progress report of a cooperative study between the Oklahoma Agricultural Experiment Station and the USDA Bureau of Plant Industry, Soils and Agricultural Engineering, in which certain phases were carried on under the Research and Marketing Act of 1946.

The authors: W. J. OATES, agricultural engineer (agent), USDA (BPISAE) Regional Cotton Mechanization Project and Oklahoma Agricultural Experiment Station, (Stillwater); R. H. WITT, research engineer, Dearborn Motors Corp., and W. S. WOOD, engineer, The Boardman Co. (Mr. Witt and Mr. Wood were formerly assistant agricultural engineers in the employ of the USDA Regional Cotton Mechanization Project and the Oklahoma Agricultural Experiment Station.)

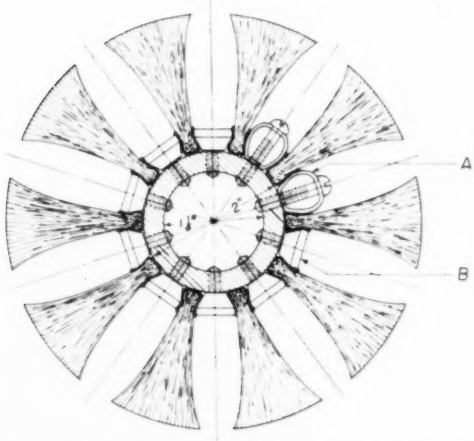

Fig. 1. Section showing details of the stripping brush of the brush-type cotton stripper.

3. Must be stiff enough to strip the boll from the plant and yet resilient enough to allow limbs and large stalks to pass through without pulling or breaking.

4. Must not take a permanent set and thus render the roll ineffective.

5. Must have the qualities necessary for a long service life.

The Fuller Brush Company furnished samples of a steel wire, tampico, palmetto, and calabar bristles and various combinations of these materials. During 1949 the calabar and the palmetto-tampico mixture were used separately and in combination with each other. Nylon and combination nylon-tampico brushes were tried in 1950.

Pneumatic Conveying System. The merits of a pneumatic conveying system have been proven in almost every cotton gin. A system of this type is rather simple and requires few moving parts. The authors believed that the cotton could be moved from the stripping rolls to the trailer rapidly and with a minimum of handling with such a system. This would eliminate the losses at the row ends and thus allow more rapid turning. An adjustable hood at the discharge would allow the cotton to fill from the rear of the trailer to the front without an additional man in the trailer. There appeared to be no need for a separator in the system, since the velocity of the air diminished rapidly after the cotton was discharged.

Construction of Machine. A one-row model of the harvester as constructed for the 1949 season is shown in Figs. 2 and 3. The brushes were mounted on a 2-in steel tubing (Fig. 1). The rolls were made up of 10 strips of fiber. These strips were applied spirally and had a 16-in pitch. Fig. 1 (B) shows the method of mounting the spiral brush strips. The spiral brush was used to get an auger effect that would aid in stripping the cotton and in cleaning the brushes.

The cotton stripped by the rolls moved down an incline by gravity to an air duct which deposited it in the trailer. The fan was arranged so the cotton by-passed it.

Rolls were made of a mixture of palmetto-white tampico and alternate strips of palmetto-tampico and calabar.

Operation. The 1949 harvesting season was ideal and no trouble was encountered. Not a single stalk was pulled during the entire season. This machine's performance was tested on four different varieties in comparison with that of a spindle picker and a commercial roll-type stripper. The strippers harvested a significantly greater percentage of the cotton than the picker in all four varieties. The brush stripper harvested a greater percentage of cotton in all four varieties, and the percentage was significantly greater in two open-type varieties. The percentage harvested, however, does not necessarily reflect the true measure of the effectiveness of each machine. The brush stripper was able to harvest without choking. This was not true of the other stripper.

The palmetto-tampico brushes lasted well, but the calabar fibers broke so rapidly that they were deemed unsatisfactory. Plans were made to investigate the possibilities of using nylon fibers as a result of these tests.

The 1950 growing season was a complete reversal of 1949. Unusually heavy rains caused excessive vegetative growth, and the worst boll weevil infestation in the history of the Chickasha area caused a great decrease in yields. A hard freeze prior to frost killed all the plants, and, by harvest time, both limbs and stalks were very brittle and snapped easily.

Several modifications were made on the machine. Nylon and nylon-tampico fibers were used in the rolls. Both straight and spiral fiber strips were used. The straight fiber strips were mounted by the use of a tubular bar, Fig. 1 (A). The use of the bar for mounting the brush strips prevented the brush fiber from bending over the sharp angle of the metal mounting strip and aided in the removal of bolls clinging tightly to the cotton plant. Rolls with 10, 8, and 5 fiber strips were tried at different ratios of roll speed to ground speed. Limited tests showed no significant difference in harvester efficiency. At the lower speeds the straight brushes had a tendency to spin the cotton rather than throw it clear. These factors need to be investigated further.

The primary troubles occurred in the conveying system. The commercial machine pulled stalks and broke limbs to such an extent that progress through the field was negligible. Little or no cotton could reach the conveying system. The brush machine broke some limbs. These became lodged in the opening of the air duct and the machine choked. An effort to force-feed the material into the system ended in complete failure. The machine was then taken to the shop and rebuilt.

Most cotton gins are equipped with 10 or 12-in suction lines which work very effectively. This machine had used air ducts with 4 x 8-in openings to convey the cotton from the rolls to a point just to the rear of the rolls. At this point they converged into a single tube 12 in in diameter. It was believed that the same degree of performance as that obtained in gins could be approached if mechanical means were used to move the cotton from the rolls to the 12-in pipe. This system increased the number of working parts, but it was thought it would nevertheless overcome many of the problems encountered with commercial machines. The brushes continued to do an excellent job of stripping the cotton. Some limbs were broken, but no difficulty was encountered in placing the cotton in the mechanical conveying system. However, as soon as the cotton reached the suction pipe, complete choking occurred. Before any further modification could be made, the harvesting season had ended. Results which (Continued on page 142)

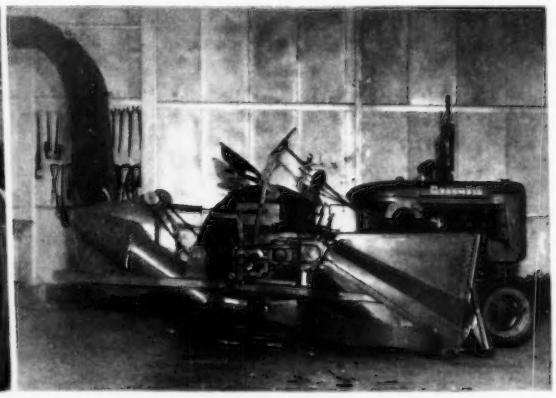

Fig. 2 (Left). Front view of the Oklahoma experimental brush-type cotton stripper used during the 1949 season, showing brush stripping rolls and wide throat opening between stalk gatherers. • Fig. 3 (Right). Side view of experimental cotton stripper, showing fan scroll and conveyor tube.

Time-Travel Studies on Dairy Farms

By Thayer Cleaver
MEMBER ASAE

A PROJECT, entitled "Physical and Economic Characteristics of Dairy Service Buildings," of which our time-travel studies have been a part, was started in 1946, under a cooperative arrangement between the Illinois Agricultural Experiment Station and the Division of Farm Buildings and Rural Housing (BPISAE), U.S Department of Agriculture. The time-travel studies has been one of the most valuable methods for measuring directly such unknowns as (1) labor efficiency of operators, (2) the proper location of work areas with respect to each other, (3) to some extent the selection, location and use of equipment, and (4) the best dimensions or range of dimensions for certain structural features. Time-travel studies have also indirectly aided in (1) reducing structural costs, (2) simplifying structures and making them more flexible, (3) simplifying and maintaining proper sanitation, (4) simplifying and improving management, and (5) making the daily operations easier and more pleasant.

To illustrate, let us consider labor efficiency. There is no single answer to the correct number of operators and the exact routine, method and manner of doing the various daily chores. But time-travel studies together with close observation can usually measure the limits beyond which human effort may be unnecessarily wasted. Studies of conventional stall barns have shown that one, two or possibly three operators may work efficiently together in a given barn in doing such chores as feeding, bedding and removing manure, so long as their travel routes do not conflict, because these chores can usually be started and completed without any delays.

The milking operations are somewhat different. They usually require more time than the other dairy chores, and sanitary regulations impose certain restrictions, either directly or indirectly, which make the problem of labor efficiency a little more difficult. Assuming that the operator or operators thoroughly understand their jobs and have a good technique and routine for handling themselves, the equipment and the animals, then a good balance of operators and equipment usually will be like this:

1. One operator with two bucket-type machines, in a 10- to 32-stall barn with good arrangements such as are shown in Figs. 1 and 2. Milk is carried directly and immediately to the milkroom.

2. Two operators and three bucket-type machines in a 20- to 40-stall barn, such as in Fig. 2. Milk is carried immediately and directly to the milkroom. One operator handles the machines and the other carries the milk to the milkroom and assists in such routine tasks as washing udders.

3. Three operators and four bucket-type machines in a 40-stall or larger barn. Milk is carried immediately and directly to the milkroom, such as in Fig. 2. Two operators each handle two machines. The third operator will be kept busy carrying milk most of the time but may occasionally help with such routine operations as washing udders. The third operator is especially needed in barns with a poorer arrangement, such as is shown in Fig. 3, where the milkroom is not in the best location.

It is recognized that only one operator in case 2 (above) and two operators in case 3 may be able to do the milking operations efficiently, but other considerations, such as the over-all time for doing the dairy chores, usually make it desirable to use the recommended number. Fewer operators may extend the over-all chore time so much that it may be false economy.

A milking room with a loose-housing system will require a different combination of operators and machines. In general, the requirements are more flexible and fewer operators are required because with good arrangements and management the work can be done faster and easier than in conventional stall barns. For example, with good arrangements and good work methods, one operator with two bucket-type machines can milk about 20 cows per hour in a conventional stall barn. There are few good operators who can milk faster than this, and the average is about 18 cows per hour. In a group of 86 stall barns studied in Illinois, Indiana and Wisconsin, the fastest time we have recorded for one operator with two machines is 21.6 cows per hour. With good arrangements and good work methods in a milking room with three elevated stalls, one operator with two bucket-type machines can milk 25 cows per hour. The fastest we have recorded for three elevated stalls is 25.8 cows per hour. Table 1 shows additional data on milking rates.

However, the small, one-story, 10-stall barn shown in Fig. 4 compares quite favorably with good loose-housing sys-

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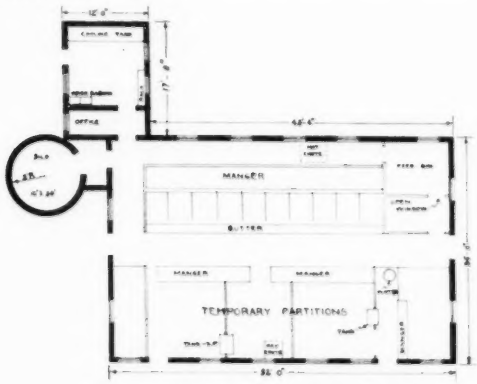

Fig. 1. Plan of a 10-stall dairy barn arrangement.

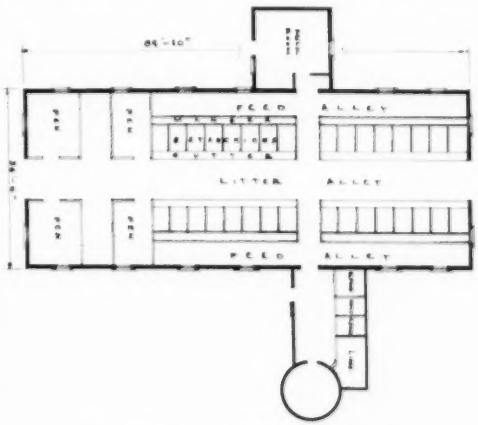

Fig. 2. Plan of a 32-stall dairy barn arrangement.

tems in some respects. Time and travel on a per cow basis will be about 80 per cent more than in a well-arranged milking room loose housing system such as is shown in Fig. 5, but it will also be about 30 per cent less than for the stall barn in Fig. 2. In addition, the over all chore time in the 10-stall barn will be quite small compared with that in the larger stall barns. However, with the arrangements shown in Fig. 5, the milking and feeding chores can be done with about 40 per cent less time and travel per cow than in the good stall barn in Fig. 2.

In contrast with the above recommended combinations of operators and machines for milking operations in stall barns, combinations for milking rooms and loose-housing systems will usually be like this:

1. One operator, two elevated milking stalls, one machine for fewer than 10 cows. Two machines would permit greater operator efficiency and milk the herd faster, but with one machine the over all time will be small. There are also economic limitations to the use of two machines. It is doubtful whether more than one machine is economically justifiable for herds of fewer than 10 cows, unless they are exceptionally good producers.

2. One operator, two elevated stalls, two machines for 10 to 15 cows.

3. One operator, three or four elevated stalls, two machines for 15 to 30 cows.

4. Two operators, four elevated stalls, three or four machines for 30 to 45 cows.

5. Two operators, five elevated stalls, four machines for herds of more than 45 cows.

In most of the above combinations, operations should be speeded up if the milk is piped to the milkroom. In any case only one operator should handle the machines. The second operator will be kept busy carrying milk, helping with the feeding, washing udders, and admitting and releasing cows. There must always be a definite division of operations among operators to prevent confusion and getting in each other's way.

As already stated, the above combinations are flexible. Sometimes the over all chore-time limitations desired by the operator will cause him to want one more milking stall or one more machine. Fig. 6 shows a flexible milking room for two, three, four, or five stalls. Fig. 7 shows a milking room for two or three stalls. Fig. 6 is a more efficient arrangement for both time and travel than Fig. 7, but with only three stalls the difference is small. Sometimes the Fig. 7 arrangement can be fitted in with existing buildings to better advantage.

Some dairymen insist on a four-stall, in-line arrangement similar to that in Fig. 7. It is not so efficient for one operator and two machines as the three stalls shown in Fig. 7, because the time and travel per cow will be greater. For example, if there are four in-line stalls instead of the three, 9 per cent more travel will be required for carrying milk to the milkroom. Also, if the milkroom in Fig. 7 is at the right end of the milking stalls instead of in its present location, 45 per cent more travel will be required for carrying milk to the milkroom; if the milkroom is to the left of the milking stalls, 16 per cent more travel will be required. Four in-line stalls may, however, be advantageous where there are two operators, one handling the two right stalls and the other the two left stalls, if they stay in their own areas most of the time and if the milk is piped to the milkroom.

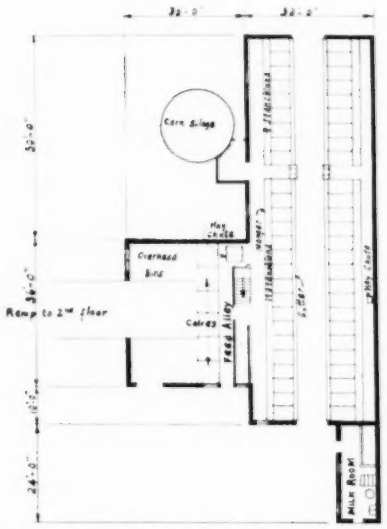

Fig. 5. Plan of a 52 stall dairy barn with less desirable location of milkroom with respect to stalls than shown in Figs. 1 and 2.

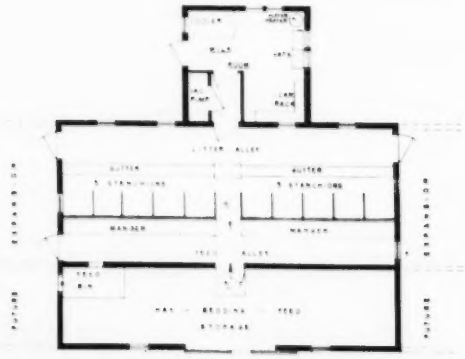

Fig. 4. Plan of a one-story, 10-stall stanchion barn.

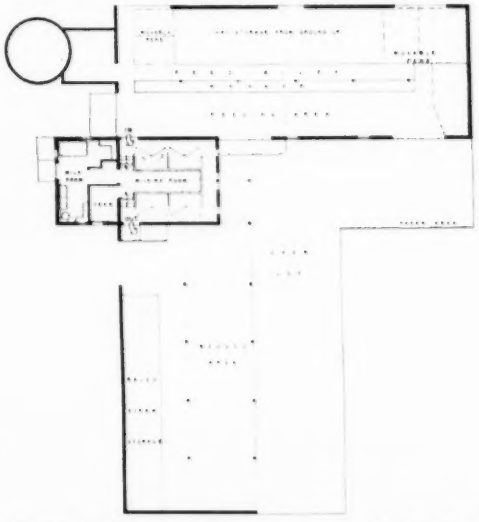

Fig. 6. Plan of a dairy barn showing a well arranged milking room loose-housing system.

The plans shown in Figs. 6 and 7 have been designed for maximum economy in both space and arrangement. The entrances to the milkroom and feed rooms are centrally located with respect to the main work areas of the stalls. The milk cooler is conveniently located for both the operator and milk hauler. Other aids which can save even more time, travel and effort, but which also add to the cost, are (1) piped milk, (2) a small feed cart centrally located in the milking room and (3) overhead bins with a feed duct to each stall manger. These plans meet the requirements of most milk-producing areas of Illinois. Comparatively few areas in Illinois require additional facilities, such as an inside toilet, boiler or utility room, dressing room for operators and office, but exceptionally large herds may justify the use of them.

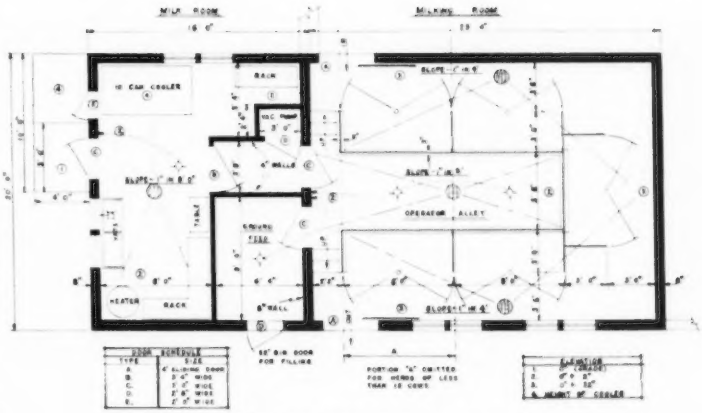

Fig. 6. A flexible milking room for 2, 3, 4, or 5 stalls

Many dairymen who have had no experience with a milking room loose-housing system want to know how many stalls are necessary, for a given set of conditions, to allow the cows ample time to eat their concentrates while being milked. Table 1 shows the time available for eating grain with a variety of combinations of operators, machines and rates of milking. The data were obtained from case studies made in dairies where the operators rate good to excellent.

TABLE 1. RATE OF MILKING COWS AND TIME AVAILABLE FOR COWS TO EAT GRAIN IN MILKING ROOMS

Elevated stall types

No. stalls used	No. milking machines used	No. operators	No. cows milked per hour	Time for eating grain, (min)	Machine type
2	1	1.0	15	8.5	Bucket
2	2*	1.0	16	6.5	Piped
2	2*	1.0	22	4.7	Piped
3	2	1.5	20	8.2	Bucket
3	2	1.0	26	6.4	Bucket
4	2	1.2	19	12.5	Bucket
4	2	1.2	24	9.5	Bucket
4	2	1.0	26	8.0	Bucket
4	3	1.7	32	6.0	Bucket
4	2	1.3	22	7.5	Bucket

*Milked piped to cooler, milk carried by hand in all other cases.

Observations and time studies of a variety of milking rooms indicate that most cows eat their concentrates in about 6 min. A few exceptionally high-producing cows will eat more and thus require more time, but 7.5 min would seem to be ample for most high producers. In conventional stall barns some cows may take as long as 12 to 15 min to eat their concentrates, but in milking rooms they learn to eat faster.

Time-travel studies can sometimes answer questions on equipment either directly or indirectly. For example, one operator decided he could milk his herd faster with three machines than with the two he had been using, because with the two machines he had some idle time. A time-travel study showed the following:

1. The operator had not washed the cows' udders properly, the cows were not sufficiently stimulated into letting their milk down by the time the teat cups were placed on them, and consequently the machines were being left on longer than necessary. This unnecessarily long machine time accounted for most of his idle time.

2. The addition of the third machine made the situation worse. The vacuum pump could not accommodate the third machine easily. Therefore, the machine time per cow increased to about twice what it should be, and he had even more idle time than before.

3. Discontinuing the use of the third machine and washing the udders properly reduced the machine time per cow to more nearly what it should be and eliminated most of his idle time. He learned that the two machines were all he could handle properly, and his over-all milking time was less than it had been with the three machines.

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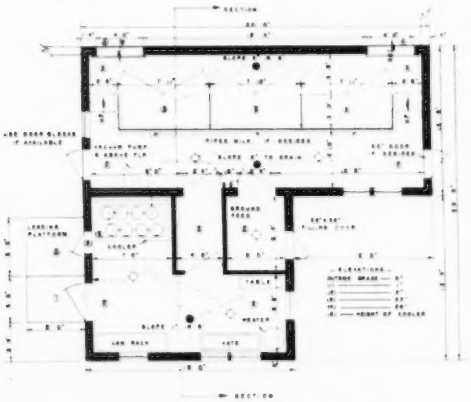

Fig. 7. A milking room for two or three stalls

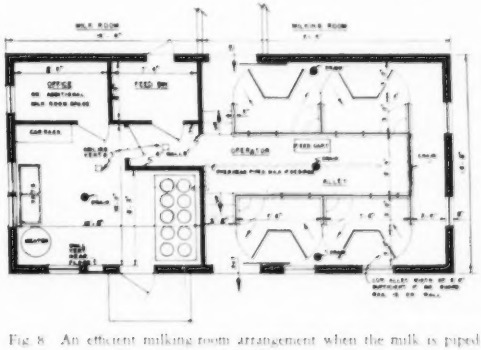

Fig. 8. An efficient milking room arrangement when the milk is piped to the milkroom

Safety and the Mechanical Corn Picker

By Charles J. Scranton
MEMBER ASAE

MECHANICAL harvesting of corn has shown a vigorous increase in the past ten years. In 1941 there were approximately 120,000 corn pickers on American farms. Ten years later, in 1951, this number had grown to 302,000. This means the number of pickers has grown more than four times in ten years. It also clearly shows that the mechanical harvesting of corn is now the accepted harvesting method.

These machines pick either one or two rows of corn at a time, are pulled by a tractor, are mounted on a tractor, or are of the self-propelled type.

Most of the pickers are in 28 states. Iowa leads with approximately 95,000 units. Next comes Illinois with 80,000, then Indiana with 18,000; Minnesota and Nebraska with 15,000 each; Ohio with 10,000; Missouri with 20,000; and Michigan with 10,000. Wisconsin, Kansas, and Pennsylvania follow with about 13,000 each. These pickers have ended the backbreaking and time consuming job of hand harvesting, and the day of the horse and wagon in corn picking is pretty well on the way out.

Increase in Accidents. With the growth in the number of mechanical pickers has come an unwholesome record of farm accidents. These accidents have been both tragic and costly. If we examine the records in Iowa for the year 1948, we find there were 454 recorded accidents with approximately 70,000 pickers in the state. Examination of the records of Illinois, Ohio, and other states in the corn belt would indicate similar tragedies.

Accidents of all types on American farms, including those with corn pickers, other machines of all types, fires, falls, animals, etc., are costing the farmers nearly one billion dollars per year. This figure is an estimate by the Farm Division of the National Safety Council and includes both direct and indirect costs of these accidents. In one state, this cost was approximately one-tenth of the state's total farm income.

The significant thing to note in connection with these farm accidents, and particularly those with corn pickers, is that almost all of them are due to carelessness. In practically no instance could the accident be traced to mechanical failure of the machine.

From some of the press notices of corn picker accidents, one might easily conceive a picture of a fiendish mechanism going out looking for a farmer or his son to maim or cripple him, and infer that the manufacturer of the machine was entirely at fault. The number of corn picker accidents per thousand machines in Iowa in 1948 was 6.2, and 5.2 in Nebraska in 1950. These machines were operating under most adverse field and weather conditions and the record does not justify the idea of a mechanical monster eager to hurt anyone who dares to operate it.

In fact, I should like to state that corn-picker development in its present stage represents the best thinking of trained engineers in the entire industry. All of them are responsible for designing safe machines. Admittedly the corn picker, like all other equipment, is not a perfect machine and will be improved from the standpoint of both performance and safety, but there is no known means by which these things can be accomplished in the foreseeable future.

Before discussing ways to safeguard corn-picker operation, let us consider some of the conditions under which a mechanical corn picker must operate. These conditions make corn-picker design a difficult problem and have a direct bearing on accidents.

Field Operating Conditions. To begin with, there is a wide variety of types of corn, and the characteristics of these types are somewhat changed by location and the weather during the growing season. These characteristics present a wide variety of snapping and husking conditions. Some corn will shell very easily, and some will husk very hard. Also the size of ears of corn varies widely. Big ears, little ears, or nubbins will be found in the same field.

Sometimes there are large stalks up to 12 feet or more in height and as big as one's wrist, while again there will be short stalks no bigger than a broomstick. In one field on rolling ground the corn may be very heavy in the low places and very thin on the high spots. In some cases the ear of corn on the stalk may be eight feet from the ground, and in other cases only two feet; it may even be lying on the ground.

At times the stalks are frozen and are hard and tough, and at other times they may be wet and green. They may also be dry and brittle, or they may pull up by the roots.

There is another condition where the stalk is broken over like a croquet hoop with both ends frozen to the ground. This means a loss of ears because the ear shank breaks off when the stalk is pulled through the rolls.

Sometimes farmers want all the husks taken off the corn, and in other cases they don't want any taken off.

There are instances where the corn is drilled in rows, and others where the corn is checkrowed with possibly four stalks in a hill.

There are other conditions where the stalks are high and have blown over or broken down because of the inroads of the corn borer. Under such a condition it is very difficult to follow the rows.

The weather condition and its effect on the corn crop are clearly exemplified by the 1951 season when there was a heavy snowfall throughout some of the states in the corn belt in the early part of November. At that time, because of delayed maturing of the crop, corn picking had just started in many places. This condition has made mechanical picking more difficult and will magnify both field losses and accidents.

To complicate the problem still further, there may be all kinds of ground conditions with mud, muck ground, frozen ground, sand, and others.

Proper Adjustments Reduce Accidents. What are some of the things which the operator can do to improve corn-picker performance and reduce accidents? In most cases, accidents are caused by neglecting to keep the picker in good condition or by a lack of understanding of the operation of the machine. It is a sad commentary that all too few operators read the instruction book which is prepared with much care by the manufacturer. Very often poor results are obtained with the picker and accident hazards increased by this lack of understanding.

The first important thing is to get on the right rows with a two-row picker and to drive so the center of the snapping rolls runs as close as possible to the center of the corn rows. If one tries to pick narrow rows with a corn picker set at 42 in. or if he drives off the row so the stalks all come in at an angle, the chances of clogging are materially increased. The records indicate that approximately 85 per cent of all corn-picker accidents occur at the snapping or husking rolls. Corn rows should be planted to correspond with the row spacing of the picker.

The snapping rolls should be properly adjusted to take care of the conditions existing in the particular field which the picker is operating. If these rolls are worn and do not drive the stalks through, they should be replaced. In the case of an

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1951, as a contribution to the Power and Machinery Division.

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emergency, it is possible to increase aggressiveness by welding beads of metal on the smooth areas.

With some makes of corn pickers, provision is made for special setscrews or insert lugs in the rolls to help pull the stalks through. These lugs are usually used in corn that is dry and brittle. If the corn is normal or damp, they may cause excessive shelling.

Increase the tension on the husking-roll springs for small corn or corn with tight husks; decrease for large ears or easy-to-husk corn. Don't try to pick the corn with weak springs or worn rollers.

The timing of the finger links on the gathering chains should be checked. Ordinarily the link on one side should be halfway between the two links on the other side of the roll.

All slip clutches should always be tight enough to handle adverse conditions. If they are too loose, clogging of the machine may result and the accident hazard increased.

After the machine has been properly adjusted, it should be driven through the field at a speed consistent with the harvesting conditions. Obviously in big, heavy corn that is down, the tractor ground speed should be reduced by dropping into a lower gear.

All safety shields provided by the manufacturer should be in place; this is particularly true of the power take-off shield on pull-type pickers.

Work of the FEI Safety Committee. The manufacturers of farm equipment make every effort to build machines which do not injure their customers. For many years the Advisory Engineering Committee of the Farm Engineering Institute has been analyzing accidents with farm equipment and making definite recommendations for safeguarding the user even though his own carelessness may have been the cause of the accident. This committee is composed of chief engineers or their authorized representatives of manufacturers of both tractors and implements.

In the early part of 1950, it was decided to appoint a subcommittee of the above-named committee to investigate the entire corn-picker situation. Such a subcommittee has been active since that time and has had several meetings. It is composed of chief engineers responsible for the design of corn pickers. A representative of the National Safety Council has been present at some of the discussions.

The first effort of this subcommittee was to gather data covering accidents, and then, if possible, to make definite recommendations for the consideration of devices that would contribute to corn-picker safety. Much work was done in the fall of 1950 and it was continued through 1951.

This subcommittee has carefully considered and followed field testing of the following devices:

1. Reversing mechanism for the rolls
2. Shields over the rolls
3. Spring mounting of the rolls
4. Stronger drive release clutches
5. Speeding up the rolls
6. Manually operated release clutches
7. Pulling rolls below the snapping rolls
8. Manual opening of the snapping rolls from the tractor seat
9. Strippers over the rolls adjustable from the tractor seat
10. Live power take-off

Special attention was not given to the shielding of the power take-off, together with sprockets and chains, because it is already accepted by the farm machinery industry that all of these must be adequately safeguarded by the manufacturer when there is danger of contact by any user in the normal operation of the equipment.

Following is a review of the experience of the subcommittee with respect to the several devices:

1 A mechanism for reversing the rolls was tried out by a number of manufacturers. While it is true that under some conditions this mechanism makes it easier to clean out the machine, it is also true that under other conditions stalks are pulled up by the roots and an additional accident hazard is created. After all, the material has to be fed back again through the rolls, and when it is once reversed it will not feed backwards without assistance from the operator, who must get off the tractor seat.

2 Shields over the rolls have been tried, but they actually create a new hazard and in certain conditions interfere with the entering of the material into the rolls.

3 Spring mounting of the rolls in some designs does not prove to be entirely adequate and at times does contribute to the shelling of the corn.

4 In some cases the drive clutches can be improved by making them stronger for better operation under the toughest conditions.

5 Speeding up the rolls from the normal speed of around 550 rpm to approximately 700 rpm does increase the capacity of the picker in some conditions.

6 Manually operated release clutches are not considered to be good safety devices. By the time one of these clutches can be operated, damage has already been done.

7 One manufacturer tried putting rolls below the normal snapping rolls, but under some conditions these rolls actually increased the accident hazard.

8 Another manufacturer has placed in production a manual device for opening the rolls from the seat of the tractor. With this mechanism, it is possible for the operator to minimize clogging by increasing the opening between the rolls and letting the material go through. This, of course, means that some shelling results, but the possibility of clogging is reduced.

9 Another manufacturer has placed manually operated strippers above the rolls. This device shows promise.

Two views of Allis-Chalmers two-row corn pickers in operation: *(left)* in checkrowed corn with stalks standing upright and *(right)* in a tangled mass of drilled corn.

10. The live power take-off is an advantage because the forward movement of the tractor can be controlled without stopping the picker mechanism.

The subcommittee's conclusion has been that any improvement in pickers which will increase their capacity to handle the heavy yield of corn now being produced and thereby prevent clogging, is one of the best safeguards which can be made. We know of no infallible device which will completely guard the user against his own carelessness.

It is obvious that a great deal of educational as well as mechanical work will have to be done. This is going to require the activities of all farm equipment dealers and many national and state agencies before this particular type of farm accident can be brought under control.

Educational Agencies to Reduce Accidents. As an indication of what can be done to bring about a reduction in accidents, the experience of an Ohio organization in 1949 stands out. A state-wide campaign was put on by the Ohio Future Farmers organization to reduce the number of corn-picker accidents in that state. This organization used all kinds of publicity, including radio broadcasts as well as personal contacts to cut the accidents in that year to less than half of the previous year. Their work not only reduced the number of corn picker accidents in the state, but made Ohio farmers safety conscious so that some of the younger generation will think in terms of safety for years to come.

It is a fact that, where safety programs are carried on by county agents, vocational-agriculture teachers, implement dealers, and other agencies in the various states, excellent results are obtained. The story must be carried to the local level through personal contacts to make farmers safety-minded. It is possible to control safety through group education in an industrial plant, but it is much more difficult to reach individual farmers throughout the nation.

The work of the Farm Division of the National Safety Council has been outstanding in promoting national safety. In spite of constant efforts to make the American public safety minded, accidents in all fields do continue. The whole safety program requires ceaseless vigilance.

Safety Rules for Corn-Picker Operation. There are many rules for normal and safe operation of a corn picker. Here are some of them:

1. Keep the picker on the row.
2. Keep the power take-off shaft covered.
3. Keep the snapping rolls in good condition.
4. Be sure the safety clutches are properly adjusted.
5. Keep riders, especially children, off the picker.
6. Don't combine hunting with corn picking. Several of the lives lost in Iowa were due to the fact that the operator carried a gun while picking corn. This certainly cannot be attributed to faulty performance of the picker.
7. Always shut off the power before dismounting to clean out the picker, if it should clog.
8. Wear snug fitting clothing.
9. Run at the correct speed of travel to meet the field conditions.
10. Read the instructions.
11. Don't use a stick to push stalks through the rolls.
12. Watch the roll adjustment and the tension of the gathering chains.
13. Shield the exhaust manifold and the sides of the engine to prevent dry material from collecting and being set on fire.
14. Use a sediment bulb which is not easily broken.
15. Keep a fire extinguisher available.
16. Keep the platform of the tractor free of obstructions over which the operator can stumble.
17. The operator should be especially careful when tired.
18. Keep untrained operators off the picker.
19. See that proper lights for night travel are provided.
20. Don't clean, grease, or adjust the machine while the power is connected.
21. The operator should always shut off the power when he gets off the tractor.

Brush-Type Cotton Harvester

(Continued from page 136)

have been obtained to date warrant continued investigation of this principle of harvesting.

SUMMARY

1. The present cotton strippers and pickers are not satisfactory machines for many sections of the cotton belt, from either mechanical or present economic aspects.

2. The combination of brush rolls and pneumatic-conveying system does an excellent job of harvesting the cotton if the plant is not entirely dead.

3. The combination of brush rolls and mechanical-conveying system works well under most adverse of plant conditions at harvest time.

4. Further investigations are necessary to determine the best type of fibers, optimum speed ranges, and most desirable conveying methods.

5. A successful machine of the type discussed would do much to mechanize cotton harvesting.

Time-Travel Studies on Dairy Farms

(Continued from page 139)

There are many structural and space problems for which time-travel studies have given at least a partial answer. Let us consider two of them: (1) storage space for concentrates and (2) storage space for dry roughages. The concentrate storage space adjoining the milking area in Fig. 5 is only a fraction of the size of that found in many dairy barns, and yet it is ample. Ground feed 4 ft deep in this space will feed 30 better-than-average cows for at least two weeks. If this room is larger, there will be some waste space, and the extra space frequently becomes a storage place for junk. This room is also conveniently and centrally located for the milking operations.

Concentrate storage can be built under the stalls near the feed boxes, but this makes the milking room dirtier and more difficult to keep clean. A small feed cart 16 by 30 in and 24 in deep can be filled in the feed room and moved to a central location in the milking room, as shown in Fig. 8. It will hold enough feed for about 25 cows, and for the farm milking plants shown in Figs. 6, 7 and 8 fewer than two steps per cow will be required for feeding. Fig. 8 also shows an efficient arrangement if the milk is piped.

The hay storage area in Fig. 5 is determined partly by the manger space requirements of the cows. A good average for manger space is 27 to 30 in per cow. The space between the feed alley and the wall to the right is more than ample for storing baled or chopped hay for the number of cows that can be accommodated at the manger at one time. This plan is based on a height of 9½ ft to the plate for the right wall, although hay may be piled as high as 12 to 14 ft next to the feed alley if desired. Since this space is more than ample for minimum hay-storage requirements, part of the space may be used for small calf pens, as shown in Fig. 5, or for extra hay storage.

This arrangement for hay storage is very satisfactory for keeping time and travel requirements to a minimum, since the hay need never be carried more than about 12 ft, and over half of it a distance of only about 6 ft. Mechanical aids, such as a hay cart, are not necessary here — in fact, they would be of little or no value. Straw-storage accommodations in the left wing are similar, except that the straw may have to be carried a little farther than the hay from storage to the area where the bales are broken.

Heat Transfers in Citrus Orchards Using Wind Machines for Frost Protection

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(Continued from the February issue)

MINIMUM TEMPERATURE DEPENDING ON SOURCE TEMPERATURES AND COOLING RATES

To grasp the concept of progressive *cooling* until heaters are fired, the radiation, conduction, and convection terms in formula [8] need to be replaced by equivalent cumulative cooling terms. Soil surface temperature and orchard temperature are practically the same, so to express all temperature differences relative to orchard temperature, only one conversion for temperature, t_o, needs to be made. According to Kepner (see Fig. 5, page 81, AGRICULTURAL ENGINEERING for February, 1952), tree-top temperature averages about 2 F warmer than that at 5 ft. It is appropriate therefore in the formulas to substitute $(t_o + 2)$ for tree-top temperature, t_u.

Of the cooling equivalents given by formulas [1], [6], and [7a], and in the last terms of formulas [4] and [5], with the slight correction mentioned, only the moisture formula [7a] is not an all night heat source. Since most of the moisture effect is reflected in decreased radiation loss, and dew formation can be considered as hourly, the heat-balance equation [8] can be rewritten satisfactorily for cumulative cooling now, ignoring only soil evaporation and the freezing of dew, namely

$$K h_{rb}(t_o+2-t_r)=\frac{c_1 k}{2C_3\sqrt{\alpha_3\theta/\pi}}(t_{is}-t_o)+\frac{c_4 K_q}{2C_4\sqrt{\alpha_4\theta/\pi}}(t_{iu}-2-t_o)+$$

$$\frac{c_2 \gamma c_p w_o}{\theta}(t_{io}-t_o)+\frac{c_3 \lambda_f w_d}{\theta_d}(t_{dp}-t_o),\ (B/hr\,ft^2) \quad . \quad [9]$$

It is now possible to convert equation [9] to find the terminal temperature of the soil. Thus the approximate formula for minimum soil surface temperature is

$$t_o=\frac{\frac{c_1 k}{2C_3\sqrt{\alpha_3\theta/\pi}}t_{is}+\frac{c_4 K_q}{2C_4\sqrt{\alpha_4\theta/\pi}}(t_{iu}-2)+\frac{c_2 \gamma c_p w_o}{\theta}t_{io}+\frac{c_3 \lambda_f w_d}{\theta_d}t_{dp}-K h_{rb}(2-t_r)}{\frac{c_1 k}{2C_3\sqrt{\alpha_3\theta/\pi}}+\frac{c_4 K_q}{2C_4\sqrt{\alpha_4\theta/\pi}}+\frac{c_2 \gamma c_p w_o}{\theta}+\frac{c_3 \lambda_f w_d}{\theta_d}+K h_{rb}},\ ^\circ F \quad . \quad [10a]$$

or more simply

$$t_o=\frac{1}{A+B+C+D}\left\{A\,t_{i.\,soil}+B(t_{i.\,air}-2)+C\,t_{i.\,orchard}-\right.$$

$$\left.D(2-t_{sky})\right\},\ ^\circ F \quad . \quad . \quad . \quad . \quad [10b]$$

With the magnitudes of the coefficients A, B, C, and D known, formula [10b] shows immediately how important is, say, the starting temperature of the soil, and whether the increase in soil conductivity is worth the evaporation chill resulting from application of water. In the three terms for heat sources, coefficient A in our typical example is 1.0, and B and C only 0.14. In this case under ordinary radiation frost conditions the starting temperature of the ground is seven times more important than that of the air. Coefficient D for net radiation loss is 0.7; and so for this example the equivalent sky temperature has nearly as much influence on minimum morning temperature as does soil temperature.

ARTIFICIAL FROST PROTECTION WITHOUT ADDING HEAT

Improving soil conductivity is one method of getting a little frost protection. If in the above example the soil had the thermal characteristics for moisture content nearly doubled, the conductivity would be increased 80 per cent and the diffusivity 80 per cent. Applying these new magnitudes, the nocturnal cooling equation indicates a minimum temperature 4 F higher than before. But the daytime evaporation chill from wetting the soil might drop the initial soil temperature 7 F as in the Lakeport test previously described, and this would counteract the gain from higher thermal conductivity for a week or 10 days. Cultivation operations, however, can increase or decrease local frost hazard. Orchards in which the ground remains fairly solid because oil spray is used for weed control seem to have a 1 to 2 F advantage over the orchards regularly cultivated.

Without considering the small amount of heat generated by the power units of wind machines, forcible modification of the typical inversion could raise the orchard temperature at the expense of air temperature above the orchard without changing essentially the heat flows represented in formula [10b]. That is, a wind machine by mixing the air to a depth of, say, 40 ft would make all the temperatures in the disturbed area more uniform, and although the fruit would be radiating a little more heat and the soil delivering a little less stored heat (because t_r might be 2 or 3 F above normal), the fruit would not be liable to frost damage as long as the air surrounding it is above the danger point. Such mixing therefore postpones the need for adding heat 3 or 4 hr, while the whole system continues to lose heat at the original rate.

There is one important change in the heat-exchange system of a protected orchard in that it now has to cope with the inflow of colder air. This calls for the inclusion of another term in the heat-balance equation, which will be considered with orchard heating.

One of the oldest proposals for frost protection, but yet to be developed, is artificial cloud screening to reduce the primary heat-loss rate. If a large-particle cloud were suddenly interposed between the cold sky and the ground after the clear-sky heat flows had produced large temperature drop, the minimum orchard temperature, t_o, would rise quickly to an intermediate level, at which a new heat balance would be established, still according to equation [8]. Then if the cloud screen reduced the net sky radiation loss rate, E_{rb}, by a fixed fraction, the cooling of the whole system would resume as per formula [10] but at a slower rate. The new equivalent starting time to be used in the cooling formula depends on how many extra hours it would have taken to bring the system to the same temperature if the screened radiation rate had existed the whole time previously. Military smoke-screen generators were tried by Collins (1946) but were found useless for long-wave screening. This is because the 0.7 micron smoke-screen droplet is at least 20 times too small in diameter. The necessary large-particle fog generators are not yet available, because very uniform particle size is needed to avoid too-rapid settling. The inflow of cold air at the screen border would depend on how extensive an area is covered. Valley-wide coverage would be best, but many damage lawsuits are likely to result if the screening is not a fully cooperative venture.

FROST PROTECTION BY HEATING IN INDIVIDUAL ORCHARDS

Because Kepner (see AGRICULTURAL ENGINEERING for February, 1952, pages 79-84) has analyzed four years of our tests on orchard heating, only a few remarks will be made here. The main difference between individual orchards and area-wide orchards is the prominent effect of a finite border.

This is most obvious on the side where cold air drift enters the orchard. No longer can the air be considered as cooling by the square mile while it gives up heat to a continuous orchard, but when orchard temperatures are held constant artificially, while natural surroundings continue to cool, the gravity drift of cold air entering the orchards becomes a virtual cold source whose magnitude varies with drift velocity and natural temperature depression.

Heat-Flow Expression After Termination of Temperature Drop by Adding Heat. Instead of using the cooling formula [10b] to interpret heat flows during artificial frost-protection operations, it is more useful to develop the equations based on constant low, surface temperature from the solution for heat flow from the surface after sudden change of surface temperature of a thick plane, as given by Jakob and Hawkins (1942, p. 47), namely

$$F_s = \frac{q}{A} = -c_1 k (t_1 - t_s) \frac{1}{\sqrt{\pi a_s \theta_2}} , \quad (B/hr ft^2) \qquad [11]$$

This differs slightly from equation [4], mainly in that the heat rate now decreases as the square root of time, instead of temperature drop varying with the square root of time. Usually by the time heating is started the temperature distribution in the soil from steady heat loss (equation [3]) will be substantially the same as for that for several hours of equation [11], so that it is useful to assume equalness and solve for the equivalent number of hours, θ_2, or else calculate θ_2 from the measured soil heat flow rate q/A at the time temperature drop is stopped artificially. A new heat-balance equation can now be developed for the steady, depressed temperature case including extra terms for heat added artificially, and now also for heat required to warm the air-drift inflow up to the control degree.

Revising the heat balance equation [8] to suit the *controlled* temperature condition with perfect distribution of heat, the radiation drive, E_{rb}, would be substantially the same as before, except for increasing slightly by the hour as the heated area becomes relatively warmer than the natural surroundings, which continue to cool until sunrise. The soil conduction and air eddy convection terms, instead of being nearly constant, now decrease with the square root of time as shown by equation [11]. No more heat is released by orchard cooling or the formation of dew because temperature is now held steady. On the other hand, heat is required to warm the inflowing cold-air drift up to the protection temperature, namely

$$E = \gamma c_p z_0 U_m (t_0 - t_b) , \quad (B/hr ft^2) \qquad [12]$$

where E is the heating required per foot of border, transverse to the air flow.

Finally, even if the small soil evaporation term is neglected, a new term is needed for artificial heat introduced (in a uniformly distributed pattern) to make the heat balance which will maintain the protection temperature. This heat source has poor efficiency, hence a coefficient C_H is needed to correct for local underheating, and also for local hot spots (which in practice sharply increase the measured net radiation E_{rb}). This makes the heating expression

$$E_H = 140{,}000 \, C_H \, w_H / \theta , \quad (B/hr ft^2) \qquad [13]$$

where w_H/θ is the amount of fuel oil per square foot burned per hour.

The heat balance equation for heated orchards comparable to formula [9] is therefore

$$\varepsilon F_{rb} (t_0 - t_r) = \left(\frac{k (t_1 - t_2)}{\sqrt{\pi a_s \theta_2}} \right)_{soil} + \left(\frac{c_p k (t_1 - t_0)}{\sqrt{\pi a_a \theta_2}} \right)_{air} - \{ \gamma c_p z_0 U_m (t_0 - t_b) \} + 140{,}000 \, C_H \, w_H / \theta , \quad (B/hr ft^2) \qquad [14]$$

Since on the right-hand side the first two positive heat-source terms are steadily decreasing and the third increasing negatively, the heating rate w_H/θ must be steadily increased to maintain a constant protection temperature.

Heat-Flow Expression for Temperature Drop in Orchards with Fixed Additional Heating. The heat-balance equation [14] is an ideal constant-temperature solution rather than one representing the usual addition of a fixed rate of artificial heat from firing a given number of heaters, or of wind machines pumping warm air down into isolated tracts. The more general heat-balance solution, therefore, is an expansion of formula [9], which would show continued cooling after firing but from a higher temperature. This case of raised temperature also includes the heat needed for warming cold-air inflow. Omitting the small terms of evaporation and dew but subtracting cold-air inflow demand (equation [12]) and adding artificial heating (equation [13]), the general heat-balance equation is

$$\varepsilon F_{rb} (t_0 - t_r) = \frac{c_1 k (t_1 - t_0)}{2 C_s \sqrt{a_s \theta_2 / \pi}} + \frac{c_a k (t_1 - t_0)}{2 C_u \sqrt{a_a \theta_2 / \pi}} + \frac{c_2 \gamma c_p w_0}{\theta} (t_1 - t_0) - \gamma c_p z_0 U_m (t_0 - t_b) + \frac{140{,}000 \, C_H w_H}{\theta} , \quad (B/hr ft^2) \qquad [15]$$

This equation can be rearranged to yield cooling rate similar to equation [10b] and show the relative importance of all initial temperatures, transfer coefficients, and artificial heating.

OBSERVATIONS OF ORCHARD RESPONSE TO FROST-PROTECTION PRACTICES

The penetration of the cold-air drift is shown by Fig. 4 (Kepner, 1951) by the meagerness of heating effect near the border when heaters are uniformly spaced throughout the orchard. The temperature profile at 4 tree rows, namely, 100 ft inside the border, shows only a 1 F gain in the trees. At 25 rows, however, there is a 7 F effective gain, and also 2 F wasted at the 60-ft level. This profile corresponds to the center of a 7-acre tract during a moderate inversion.

The border effect makes the heating of single acres at least twice as expensive as the cost per acre in mass heating, but heating a 25-acre tract using about 1,000,000 Btu per hr acre 1 F (in a 5½ F inversion) comes close to ordinary practice in mass heating. The ultimate practice reported by Newcomb (1949) in a 600-acre tract was about 1 F for 600,000 Btu per hr acre. Response to heating is less on nights of weak inversion, and is so difficult without a "ceiling" that neither heaters nor wind machines can be considered satisfactory frost protection means where there is no warm air overhead.

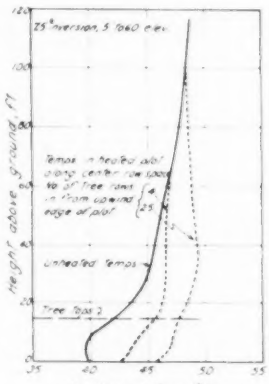

Fig. 4. Change in air temperature profile with distance from border produced by uniformly distributed orchard heaters (50 per acre) for a night with medium inversion. Solid curve indicates condition before heaters were started; broken curves the temperatures 4 and 25 rows in from upwind edge of orchard. In this case the effect of the heaters was noted far above the tree tops which indicates considerable loss. (From Kepner, unpublished project report 400-a)

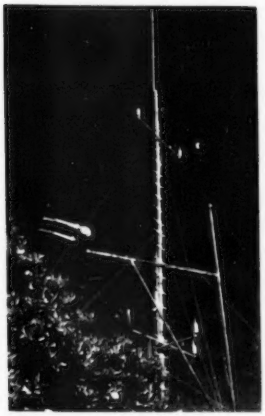

Fig. 5. One of three 65-ft masts used for the climatic observations in the 1951 tests at Riverside, Calif. Anemometers were mounted on this mast at the 80-in., 26-, 45- and 60-ft levels, thermocouples at 6 different levels, and radiometers at the 20-ft level. Six 40-ft masts were also used.

INSTRUMENTATION FOR MEASURING THERMAL RESPONSES TO WIND MACHINES AT RIVERSIDE, CALIF., FEBRUARY, 1951

Significant responses from wind machines depend more directly on temperature inversion than do heaters, and they are probably more sensitive to variation in air-drift velocity. Field 1 at the Citrus Experiment Station where the 1951 tests were made is in a region of moderate-to-fast air drift, and so a continuous record of temperature profiles and of air-drift velocities and directions was needed. Typical temperature and velocity profiles were already known from the previous work. The only important change is that the trees are 6 ft taller, the tops now being at about 18 ft. The levels for measuring temperatures, therefore, were raised, the 1951 height of 26 ft being considered as clear of the orchard as was the previous 20-ft level.

Fig. 5 shows the 65-ft installation of Station A-2 at the updrift border of the test tract 200 ft east of the wind machine. The air temperature observation levels are at 20 in., 80 in., 16 ft, 26 ft, 40 ft, and 65½ ft. Soil temperatures were measured at $-\frac{1}{8}$ in., -4 in., -20 in., and about -60 in. Six heat-flow plates were at $-\frac{1}{8}$ in; the radiometers were at 20 ft; and the sensitive cup anemometers were at 80 in., 26 ft, 45 ft, and hot thermocouple anemometer at 60 ft. All the stations covered about 10 acres. Outside reference stations were essential; therefore, the installation as shown in the map (Fig. 10) is about 1400 by 1800 ft.

The major reference station, A-1, is 1130 ft east, and 225 ft north of the wind machine. This station has the same elements as A-2 except the radiometers. Two other reference stations, B1 and B3, 700 ft north and 625 ft east, have 40-ft masts for air temperatures and velocity. These three mast stations also include adjoining tree stations with thermocouples at 80 in. and 16 ft. A fourth tree station, T3, 880 ft east of the wind machine, is also used as an outside reference station because no response has been detected at this distance updrift from the machine.

To get an average measure of orchard response, five additional 40-ft masts were installed and 22 trees were equipped with 6 thermocouples, the N, S, E, and W couples at 80 in being connected in parallel this year to get original average readings, and similarly the N and E couples at 16 ft. All the tree thermocouples were mounted approximately one-third the distance through the foliage from outside toward the hollow center. To avoid servicing thirty odd ice-baths, the reference junctions were buried in the ground about 60 in deep. Then with several miles of multiple-conductor cables, 116 pairs of copper leads were brought to 9 automatic recorders in the field house.

Test Procedure Under Steady Radiation but Variable Velocity Conditions. Conditions at Riverside on calm, clear nights were typical for radiation frosts, but rarely were steady. The most significant disturbance was due to an erratic gravity flow of cold air. The outside station, B-2, in an open field, proved unusable, because the air flow was so much freer there that the 80-in temperatures were sometimes 10 F warmer compared with the 4 stations in the orchard, as previously described. Sometimes, as seen in Fig. 6, there seemed to be pulse flow with peak velocities sufficient to almost wreck the natural inversion. In other words, natural changes were sometimes as large as the operation responses to be measured.

The technique for testing thermal responses to wind-machine operation, therefore, had to be carefully established for rigorous statistical interpretation to overcome the large variations in natural conditions. Tests were run only on clear nights with regular drift and temperature below 40 F. The first precaution in testing was to space each operation to pro-

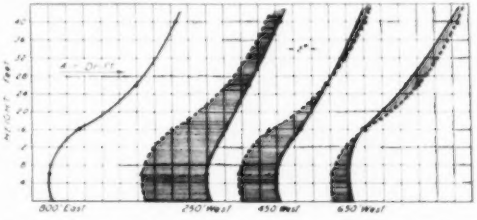

Fig. 7. Effect of 90-bhp wind machine on air temperature profile at 250, 450 and 650 ft downdrift from machine. The first heavy curve shows profile in area unaffected by machine. At 250 ft downwind the air temperature was increased about 7½ F at the 8-ft level, but only 2 F at 40 ft. The temperature modification decreases rapidly with distance, as shown by the shaded portions of the graph.

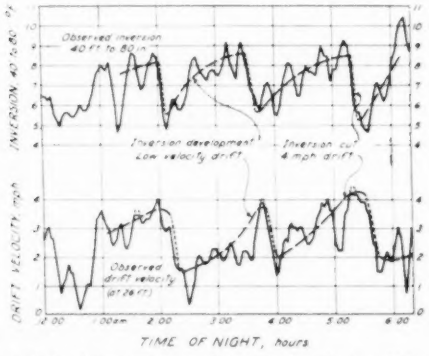

Fig. 6. Pulse flow of gravity air drift shown by velocity at 26 ft compared with observed air temperature inversion between 80 in. and 40 ft. Inversion collapsed whenever drift velocity reached 4 mph.

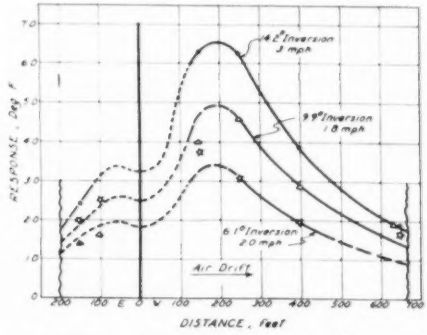

Fig. 8. Air temperature increase in the trees produced by one 90-bhp wind machine at different distances downwind from machine. Curves shown for three different inversions, 6.1, 9.9, and 14.2 F.

vide at least a half hour transition period and a 60-min averaging period. The second precaution was to reverse the sequence of operations starting at midnight alternately with wind machine and next night with heaters if the same weather type (BROOKS, 1951) prevailed. As a third precaution, pairs of runs were repeated to get four similar nights on each major test. Unfortunately the spells of clear weather failed to last long enough to maintain that schedule for minor tests. Altogether 30 nights of tests were completed in 1950-51.

Table 1 shows the general conditions for the 8 nights of tests reported here. The net radiometer readings during heating are not reliable because the radiometers were too close to two heaters to "see" an average condition during heating.

When all the relationships between natural temperatures, heat flows, and velocities are determined, it will then be possible to correct for the observed perturbations and reach new more consistent interpretations of machine and heater effects. Sticking, however, to the schedule of one hour's averaging at the end of each phase of the test, a large residual effect is found at the end of tests when burning heaters last. Some residual effect is to be expected because in the test tract all during frost-protection operations not as much heat has been drawn from the soil as in the unheated areas where the reference stations are located. The plotted points in this report

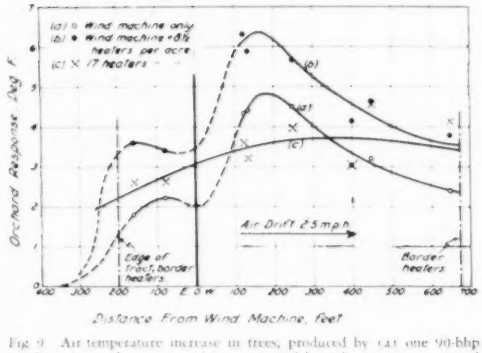
(a) ● Wind machine only
(b) ● Wind machine + 8 heaters per acre
(c) × 17 heaters
(a)
(b)
(c)
Air Drift 2.5 m.p.h.
Edge of tract, border heaters
Border heaters
Orchard Response, Avg. F
Distance From Wind Machine, feet
400 300 200 100 E 0 W 100 200 300 400 500 600 700

Fig. 9. Air temperature increase in trees, produced by (a) one 90-bhp wind machine, (b) same machine supported by 8 heaters per acre, and (c) 17 heaters alone per acre. Within 400 ft of wind machine the machine seems to be as effective as 17 heaters per acre. The inversion was 10 F; the wind machine's effectiveness depends more on the inversion than does heater response.

TABLE 1. OPERATIONS AND CONDITIONS OF TESTS 7, 8 and 17 to 22, RIVERSIDE, CALIFORNIA, 1951

Operation	Oper. Time	Data Period	Net Rad.	Soil Heat*	Inver.	Wind	Soil Temp.	Dewpoint	Air Temp.	Clouds	Wea. Type	Disturbance
TEST 7	Jan. 6-7		B/hr ft²	B/hr ft²	deg F	mph (26 ft)	at 4 in.	at 4:30p.m.	Min.			
Natural	Until 11:30p.m.	10:30-11:20	m	m	13.7	2.1 ESE	m	16°F		0.0	1	Warm gusts at edges
Wind Machine #1	11:30-1:00a.m.	Mtr. -12:50	m	m	16.6	2.6 F	m			0.0		
Remarks: Previous day clear, 8 mph wind, 24-hr avg. soil temp. 53.1°F. Contrary to p.m. dewpoint had white frost on grass and loose ground.												
TEST 8	Jan. 7-8											
Natural	Until 11:30p.m.	10:30-11:20	20.6	m	14.8	2.6 E	m	9°		0.2 Cs	1	Weak warm gusts in orchard
● M. #1	11:30-1:00a.m.	Mtr. -12:50	22.5	m	13.4	1.8 SE	m			0.0		Strong warm gusts
Remarks: Previous daytime clear, 10 mph wind NW, 24-hr avg. soil temp. (4 in), 52.3°F.												
TEST 17	Jan. 31-Feb. 1											
Natural	Until 11:20p.m.	10:20-11:20	21.7	7.1	5.7	2.4 SE	44.7°F	29°		0.5 As	1	Cleared at 10:55p.m.
● M. #1	11:30-1:00a.m.	Mtr. -1:00	21.8	16.0	6.2	1.7 SE	44.1°			0.0		
● M. #5 heat. A	1:30-3:00a.m.	2:00-3:00	29.1	16.2	7.0	3.1 E	42.7			0.0		
17 heaters A	3:15-5:00a.m.	4:00-5:00	29.1	14.7	7.4	2.9 SE	41.2			0.0		Warm gusts at end
Natural	After 5:15a.m.	5:45-6:45	23.0	12.0	7.7	2.3 NE	40.4		29.9°F	0.0		
Remarks: Previous day clear, little wind but mostly calm, 24-hr avg. soil temp. (4 in), 49.6°F. Net radiometer was exposed to nearby heater.												
TEST 18	Feb. 1-2											
Natural	Until 11:50p.m.	10:45-11:45	21.7	15.4	12.4	3.1 E	43.4	20°		0.0	0	Warm gusts
17 heaters A	12:15-2:00a.m.	1:00-2:00	25.0	14.7	8.3	2.9 E	41.8			0.0		Warm gusts
● M. #5 heat. A	2:30-3:30a.m.	2:45-3:45	25.0	12.0	10.0	2.9 E	40.8			0.0		
● M. #1	4:00-5:30a.m.	4:30-5:30	20.5	11.6	12.3	2.9 E	40.0			0.0		
Natural	After 5:30a.m.	6:00-7:00	18.7	12.1	11.4	3.4 E	39.6		27.4°	0.0		Warm gust in first part
Remarks: Previous day clear, wind from NW up to 15 mph, 24-hr avg. soil temp. (4 in), 49.6°F.												
TEST 19	Feb. 2-3											
Natural	Until 11:45p.m.	10:45-11:45	18.4	14.1	12.6	2.7 E	44.8	26°		0.0	0	
17 heaters A	Mtr. -2:00a.m.	1:00-2:00	29.0	14.0	11.4	2.4 E	43.2			0.0		Weak warm gust at 1 a.m.
● M. #5 heat. A	2:30-3:45a.m.	2:45-3:45	27.2	14.0	10.0	2.2 SE	42.2			0.0		Warm gusts 2:30-3:30
● M. #1	4:00-5:30a.m.	4:30-5:30	17.8	12.9	11.9	1.8 SE	41.1			0.0		
Natural	After 5:30a.m.	6:00-7:00	16.0	11.8	10.6	2.1 E	40.6		29.6°	0.0		
Remarks: Previous day 2:10-6:10 Clouds (Cu, As), 24-hr avg. soil temp. (4 in), 51.1°F.												
TEST 20	Feb. 3-4											
Natural	Until 11:30p.m.	10:30-11:30	16.7	12.3	9.4	1.4 E	47.3	25°		0.0	2	
● M. #1	11:30-1:00a.m.	Mtr. -1:00	18.0	12.1	11.4	2.0 E	46.3			0.0		Warm gust at 83
● M. #5 heat. A	1:15-3:00a.m.	2:00-3:00	25.1	12.0	10.6	2.7 E	45.1			0.0		
17 heaters A	3:15-5:00a.m.	4:00-5:00	23.2	12.3	10.7	2.0 E	43.9			0.0		
Natural	After 5:10a.m.	5:40-6:40	18.9	11.4	10.0	2.5 E	43.1		31.7°	0.5 As		
Remarks: Previous day clear, little wind from west, very warm (Max., 74°F), 24-hr avg. soil temp. (4 in), 54.2°F.												
TEST 21	Feb. 4-5											
Natural	Until mtr.	11:00-mdt	16.8	12.0	7.7	2.5 E	48.2	34°		0.0	2	
17 heaters A	12:15-2:00a.m.	1:00-2:00	23.3	11.0	7.4	1.8 E	46.8			0.0		
● M. #5 heat. A	2:15-3:45a.m.	2:40-3:40	21.6	10.6	7.1	1.8 E	45.9			0.0		
● M. #1	4:00-5:30a.m.	4:30-5:30	15.2	10.1	5.7	2.5 SE	45.1		36.3°	0.0		Steady temp. rise in orchard
Natural	After 5:30a.m.	6:30-7:00	15.8	9.1	6.9	2.9 SE	44.5			0.0		
Remarks: Previous day clear, little wind, very warm, evening light fog in orchard, 24-hr avg. soil temp., 54.6°F.												
TEST 22	Feb. 5-6											
Natural	Until 11:30p.m.	10:20-11:20	17.3	11.5	6.7	2.5 E	48.8	46°		0.0	2	
● M. #1	11:30-1:00a.m.	Mtr. -1:00	18.1	11.3	6.4	2.0 N	48.2			0.0		
● M. #5 heat. A	1:00-3:00a.m.	2:00-3:00	20.4**	11.1	6.1	2.8 E	46.8			0.0		Warm gust, 35 min
17 heaters A	3:20-5:00a.m.	4:00-5:00a.m.	19.3**	10.5	5.0	2.1 NE	45.7			0.0		Warm gust, 20 min
Natural	After 5:10a.m.	5:40-6:40	20.4	7.0	2.5	3.0 SE	45.1		35.5°	0.0		Strong warm gusts
Remarks: Clear, little wind, evening light fog in orchard, 25-hr avg. soil temp. (4 in), 54.9°F.												

* Soil heat flow was measured at outside station A1 in an open space probably representing a little more than average for the whole orchard.

** Radiometers over tree and shielded from heaters.

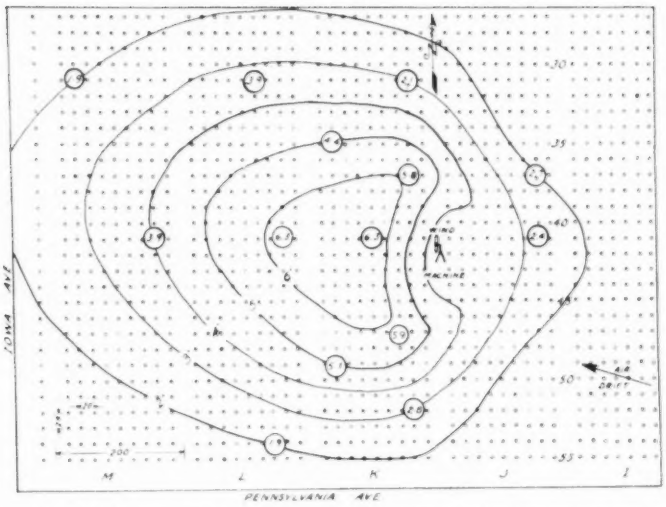

Fig. 10. Map of experimental orchard at Riverside, Calif., showing orchard response isotherms for one 90-bhp wind machine, on a night when the inversion was 14 F. The 2 F isotherm encloses about 10½ acres (approximately 8½ hp per acre). Sweep speed was 180 deg westward arc in 4 min, 180 deg eastward arc in 1⅓ min.

are, therefore, of statistical findings with only one correction for residual effect of heaters, but the curves are shaped according to our present understanding of their probable form. It is to be expected that these first findings will be rough, but as seen in Figs. 7, 8, 9, and 10 they are apparently highly significant.

In a comparison between heaters and wind machines, the main difference in modification of temperatures is that the wind machine produces little change in air temperature at the 40-ft level, while the heaters raise it. The decay of modification with distance is shown for tests 7 and 8 in Fig. 7. The general effect to be noticed is that successive temperature profiles tend with distance to revert to the original updrift inversion. It is necessary, therefore, in area protection to have a machine every 500 or 800 ft to keep mixing the air as fast as the cold stratification tends to reform. One factor needs further investigation, namely, the carry-over of the chilling at the 40-ft level. This lowering does increase the temperature gradient, tending to bring more heat down by eddy convection from overhead, but unless this plus engine heat completely makes up for the heat not drawn from the ground the wind machine farthest updrift will make conditions less favorable for other machines downdrift.

To show more clearly the response versus distance from wind machine, Fig. 8 has been prepared without correction from tests starting with machines. Downdrift the rough findings are certainly definitive, but there is too big an irregularity in the updrift direction, possibly due to the weakness of the blast sweeping three times normal speed on this side. After all the tests have been analyzed, the proper corrections which will explain this defect will probably become evident. The dotted interpolations in the central region are brought to minimums at the machine because this was our finding at Oxnard (Brooks '48, *California Agriculture*).

The three response curves from tests 17 to 20 shown in Fig 9, found for (a) single 90-bhp wind machine, (b) same machine supported by 8½ heaters per acre (with moderate border heaters), and (c) 17 heaters per acre alone, show indisputably that in this orchard with a medium inversion (10 F) the single wind machine does about as well within 350 ft as 17 heaters per acre. The combined response of machine plus 8½ heaters per acre seems to be equivalent to about 22 heaters per acre instead of 25. The discrepancy is easily explained by the fact that the gain by wind machine depends on the inversion. That is, for zero inversion there would be zero machine response but some heater response, and the wind-machine help would then be based entirely on the heaters. In general, although the distribution of response varies between the two systems, both provide frost protection in degrees that can be evaluated on an economic basis.

The area response for tests given in Fig. 10 with a 14 F inversion shows 2 F or more protection of 10½ acres, namely about 8½ hp per acre. There is quite a reduction in acreage protected 4 F because of the cold area around the base of the machine, but downdrift there is strong protection (4 F) for 4 acres. The existence of the cold spot near the machine is verified in Fig. 2 (p. 74, February issue), where the near wind machine is seen to be closely surrounded by frozen foliage, while providing frost protection practically to the tract edge.

CONCLUSION

The foregoing analytical study presents only drastically simplified interpretations of typical frost protection problems. There are endless detail questions, such as the major problem of eddy convection in stable air, still unsolved, with dozens of theories not yet fitting observed rates satisfactorily. It is hoped, however, that this report gives a fair idea of the interaction of four modes of heat transfer during radiation frosts and demonstrates the practical use of mechanical means for frost protection.

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(Continued on page 154)

Heat and Moisture Loss from Swine

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THE physiological responses of farm animals to environmental conditions should affect the design of animal shelters, and at least some of these responses deserve consideration by the designing agricultural engineer. The most important of these, the heat and moisture losses from the animals, govern the structure's environmental conditions and, therefore, the ventilating system necessary to maintain a desirable range of environment for the animals.

Measurements of the total heat and moisture loss from swine were made in the California psychrometric chamber, as part of cooperative studies between the U.S. Department of Agriculture and the divisions of agricultural engineering and animal husbandry of the University of California at Davis. These measurements were made for environmental temperatures ranging from 40 to 100 F, with identical temperatures for air and wall surfaces. The sensible heat loss from hogs of various weights under several conditions of environmental temperatures, as determined in this project, has been previously reported in AGRICULTURAL ENGINEERING by Kelly, Heitman and Morris (11)*, and the effect of various air temperatures and relative humidities on other physiological reactions of swine by Heitman and coworkers in the *Journal of Animal Science* (2, 8).

This paper reports on the total heat loss from swine weighing 60 to 350 lb, in environmental temperatures ranging from 40 to 100 F. The total heat is partitioned into latent heat loss, or the heat of vaporization, and the several avenues of sensible heat loss. The rate of water removal from the chamber is compared with the amount released by the animals as vapor, and also with the amount consumed. For sows with litters, at environmental temperatures of 60, 70 and 80 F, data is presented for the eight weeks between farrowing and weaning.

Equipment and Instrumentation. In the California psychrometric chamber the animals were housed in a single chamber, 9 ft x 14 ft x 7 ft high, separated from an enclosing outer chamber by a 3-ft space on all sides. As described by Kelly et al (11), and by Heitman, Kelly and Hughes (4), the chamber was neither a calorimeter nor a respiration chamber; it was primarily a means of obtaining a desired environmental condition. From the air conditioning system air was distributed to the inner chamber through four inlets, one located in each corner of the room, and exhausted through two outlets. In the outer chamber an air-circulating system, with cooling coils, maintained a uniform air temperature approximately the same as that in the animal chamber.

This chamber was remodeled so that (a) the volume of air passing through the chamber can now be accurately measured, (b) the wet- and dry-bulb temperature of air entering and leaving the chamber can be completely described, (c) the inner and outer chamber can be maintained at the same temperature, minimizing the transfer of heat between the two, and (d) any transfer of heat that does occur between the two chambers can be measured. The psychrometric chamber, then, was remodeled to serve as an air calorimeter. In our experiments, changes in heat and moisture content of air passing through the room were used as a measure of the total heat produced by the animals, after correction for any gain or loss of heat through the chamber surfaces.

The amount of air flowing through the chamber is measured by a long-radius, low-ratio nozzle installed in one of the outlets. This nozzle, with a 6-in throat, was constructed by pouring casting plaster around a wood form of the shape specified by the power test codes of the American Society of Mechanical Engineers (5). It was impractical to calibrate the orifice in place in the chamber, to determine the exact nozzle coefficient. However, the fact that the air velocity through the nozzle was always above 2,000 fpm indicated that the Reynolds number would be on the order of 10×10^4. The nozzle coefficient at this level would not be below 0.978 (5). A coefficient of 1.00 was used; this resulted in an error of about 2 per cent, or 40 lb of dry air per hour (9 cfm at 70 F). This error was included in the over-all calibration factor discussed below. The pressure drop through the nozzle, approximately 0.25 in water gage, is measured with a vernier-equipped Hook gage manometer. The second air outlet from the chamber, along with three of the four inlets, was closed off. Within the chamber, pressure averaged about 0.018 in mercury above atmospheric pressure.

The change in condition of air passing through the chamber is determined by wet and dry thermocouples placed in the entering and leaving airstreams; temperature levels were recorded on a 16-point, Brown strip chart potentiometer, range 0.5 to + 2.0 mv. The thermocouple wet bulbs, using absor-

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*Numbers in parentheses refer to the appended references.

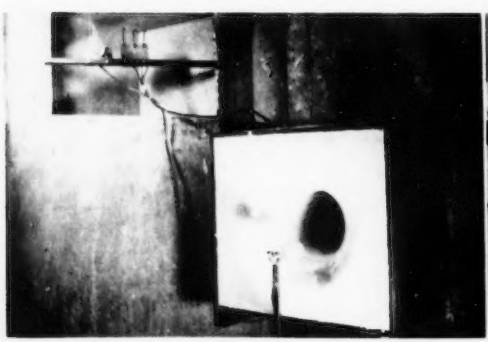

FIG. 1 (*Left*). Interior of air calorimeter showing orifice nozzle over air outlet, and the thermoelectric wet-bulb depression instruments in both inlet and outlet. The outlet instrument was later moved to the low-pressure side of the orifice throat. • FIG. 2 (*Right*). Sow and litter in air calorimeter. Note heat flow meters on wall, pig creep in corner, overhead water tank, and feed trough.

bent tissue for wicks, have been described in AGRICULTURAL ENGINEERING (6). The wet-bulb depression thermocouples are arranged on plugs so that the outlet instrument can be removed and placed beside the inlet instrument at intervals during a calorimeter run. This provides a means of checking the response to identical conditions of temperature, humidity, and air flow. A view of both the orifice nozzle and the wet-bulb depression instruments, installed in the chamber, is shown in Fig. 1.

The outer chamber is cooled slightly below the temperature of the inner chamber by manual adjustment of valves controlling the flow of chilled brine through the coils (4). The air temperature is then raised to that of the inner chamber by electric strip heaters thermostatically controlled. Even though the two chambers are maintained at the same temperature, there is occasional heat transfer between the inner chamber and the high heat capacity walls, as a result of sudden increases in heat loss from the swine, the use of electric lights, or the presence in the chamber of an attendant. The rate and direction of this heat flow is measured by five small heat-flow meters cemented to the walls and the ceiling, in locations representative of a given area of surface (6). The output, in millivolts, of the heat-flow meters is continuously recorded on the potentiometer.

The chamber was calibrated by adding various known amounts of heat from low-temperature, electric strip heaters, and by spreading known amounts of water on the the dry floor. For the heat calibration, 36 tests were made, totaling 635 hr of operation, and covering the temperature range of 50 to 90 F. Rate of electric heat input varied from zero to 3415 Btu per hr. An over-all calibration factor for the chamber was obtained from these tests and the data adjusted accordingly. At 1700 Btu per hr, the average heat loss from four lightweight hogs, the standard deviation of the measured heat from the electric heat input, was 99 Btu per hr. At heat levels higher and lower, the expected error was somewhat greater. The same tests indicated that measurements of water were not in error by more than 0.04 lb per hr. Further tests, when known amounts of water were spread on the floor, indicated that measurements of water vapor removal in the air were accurate to within ± 5 per cent.

Heat and Moisture Transfer Calculations. For the calorimeter run at each environmental temperature, total heat loss from the animals was determined from the pounds of dry air passing through the orifice, and the increase in heat content of one pound of dry air as indicated by the rise in wet-bulb temperature. To this amount was added the heat lost through the floor by conduction and the heat loss or gain through the chamber surfaces as measured by the heat-flow meters. The total amount of water removed from the chamber was determined by the increase in moisture content of a pound of air as it passed through the chamber.

The heat lost by radiation, convection, and conduction, was calculated by the method described by Kelly et al (1). The surface area was determined from the Brody-Comfort formula (7), $A = 0.634W^{0.655}$, where the area A is in square feet and the weight W in pounds. The formula gives the *total* surface area, which differs from the *exposed* area. For environmental temperatures of 80 F and above, each animal was considered separately since there was very rarely any huddling or piling up at these temperatures. Measurements indicated that, for radiation calculations, 75 per cent of the hog surface area was exposed; for convection, 80 per cent and for conduction, 20 per cent.

At environmental temperatures of 60 F and below, huddling of the lighter-weight animals was common. The inner hogs of a huddled group were considered to have 20 per cent of their surface area losing heat to the floor by conduction, 40 per cent losing heat to the air by convection, and 35 per cent losing heat by radiation. About 40 per cent of the surface area contacted other animals. At an environmental temperature of around 70 F the lightweight pigs seemed to have no fixed habits of huddling; so, for this environment, the sensible heat loss calculations were not made. For the same reason, the calculations were not made below 60 F for the heavy hogs.

For the calculation of heat loss by radiation, observations with the Hardy radiometer on seven points of the hogs' surface were averaged, and readings with the same instrument were made on the wall surfaces. To satisfy the Stefan-Boltzman formula, the shape factor of the animal with respect to the room was taken as unity, and the hog surface emissivity as 0.92.

For the convection heat losses, the air temperature was taken as the temperature of the air at the orifice outlet, and the hog surface temperature as obtained by the radiometer. The surface thermal-conductance factors as given in the curves published by Kelly et al (1) were modified to allow for differences in respiration rates of each group. The respiration rate was found to influence the conductance factor through the effect the "fanning" of the animals sides has on the rate of air flow over the surface.

The rates of conduction heat loss to the floor were measured with heat-flow meters. Observations indicated that, over a 24-hr period, these losses should be based on 20 per cent of animals' surface in contact with floor 80 per cent of the time.

Procedure and Tests. Animal management and conditions within the calorimeter were kept as similar as possible to actual farm conditions. Animals in groups of four or five were brought to the chamber and "gentled" for a week or two at 70 F. They were given all the feed they would clean up, and water at the environment temperature was available at all times. The 20-gal supply tank (Fig. 2) which held several days' supply, was housed in the chamber and replenished daily. The air velocity in the chamber was held at 15 to 30 fpm, and the rate of flow through the chamber to about 20 changes per hour. The relative humidity was about 50 per cent at all environments except 40 F, at which temperature the relative humidity ranged between 60 and 70 per cent. No bedding was used for the growing and fattening animals but a small amount of wood shavings was furnished the small pigs.

The animals were weighed at the start of each one-week feeding and weight gain trial; at the end of this period, they were again weighed and the environmental temperature was raised or lowered ten degrees. By this procedure each group, except in the instances noted, was tested by ten-degree steps through the entire 40 to 100 F temperature range. At each temperature a calorimeter run was made on the last three days of the test. In the case of sows with litters, the sows were brought into the chamber several days before farrowing and were kept there at a constant temperature for a period of eight weeks. Pigs were fed in a creep in one corner of the chamber as shown in Fig. 2.

Two types of tests were made in the calorimeter: (a) measurement of effect of environmental temperature between

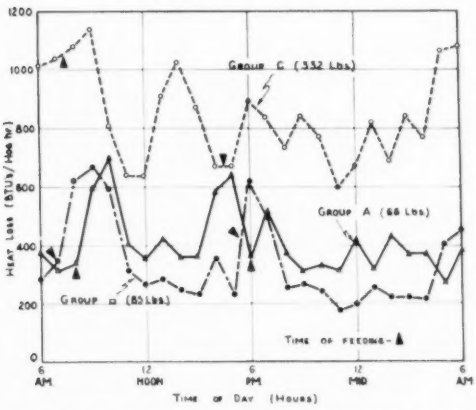

FIG. 3. Hourly total heat loss from one hog of each of groups A, B, and C, for 24-hr period, at an environmental temperature of 60 deg F. Feeding times are shown to indicate the increase of heat loss afterwards

40 and 100 F on heat and moisture loss of light and heavyweight growing and fattening hogs and (b) heat and moisture loss from sows with litters during the first eight weeks after farrowing.

Effect of Environmental Temperature on Growing and Fattening Hogs. Three groups of growing and fattening animals were used for measuring the effect of environmental temperature on heat and moisture loss, as follows:

Group	No. of hogs	Breed	Sex	Weight, lb
A	4	2 Hampshires		
		2 Duroc	gilts	42 to 124
B	5	3 crossbreds*	2 gilts	51 to 144
		1 Duroc	3 barrows	
C	4	Duroc	barrows	264 to 380

*The crossbreds were Duroc x Poland China.

The total hourly heat loss at 60 F for one "average" hog of each group is shown in Fig 3, for a 24-hr period. At the time of these particular tests, the "average" hog of group A weighed 66 lb, of group B, 85 lb, and of group C, 332 lb. The greater heat loss after feeding is indicated. The animal's movement around the chamber increases the heat loss by convection, because of increased air movement over its surface as well as the fact that the surface area exposed is greater than when the animal is lying in its usual prone position. Heat loss then changes continually, and for purposes of designing ventilation systems no one figure will accurately define its limits. The changes would be still greater if only one hog from each group had been measured; the data shown gives the average hourly heat loss of the four or five animals in the calorimeter at the time of measurement.

In Figs. 4, 5 and 6, the total heat loss per hour over the environmental range of the tests is shown for one "average" hog from each group. Each point on the graphs is based on hourly data from several 24-hr runs. The part of the total heat lost by evaporation, convection, radiation, and conduction, is shown for each group, as measured by heat-flow meter and radiometer readings. Under the low air velocities maintained in the calorimeter, the heat loss by radiation and convection was about equal. A higher air velocity would have increased the rate of heat loss by convection, produced a lower hog surface temperature and therefore decreased the loss by radiation. For each group the rate of loss by evaporation decreased from a maximum, amounting to most of the heat, at 100 F, to a minimum at the lower temperatures. Evaporation was not calculated for the lightweight hogs of groups A and B at 70 F (Figs. 4 and 5) because of their indefinite habits at this temperature in regard to huddling. Similarly, below 60 F, the large hogs of group C (Fig. 6) did not huddle at all times; so calculations could not be made below that temperature. The center section of each of the three figures shows the effect of environmental temperature on the relations among the water drunk by the pigs, the water removed in the ventilating air, and the water lost as vapor by the animal through the lungs and other moist surfaces. The amount of water drunk was measured frequently by a glass sight-gage on the 20-gal tank. The rate of water removed from the chamber was calculated from the amount and change in condition of air as it passed through the chamber. The amount of water furnished as vapor by the hog is the heat lost by the animal by evaporation divided by 1040 Btu per lb., the latent heat of evaporation of water at 70 F.

The amount of water removed in the ventilating air was considerably greater than that furnished in the form of vapor by the hogs, since it included moisture vaporized from the feces and urine and from the drinking trough. The ratio between the two varied with the environmental temperature, with location of the place of urination with respect to the floor drain, and whether or not lime was used on the floor. The lime held the water in a thin layer, allowing good exposure to the air for evaporation; so the only way that water could get out of the room was through the ventilating air or with the feces when the chamber was cleaned. With group A (Fig. 4) lime was used to dry the floor and practically no water went down the drain; also, this group of pigs urinated at the end of

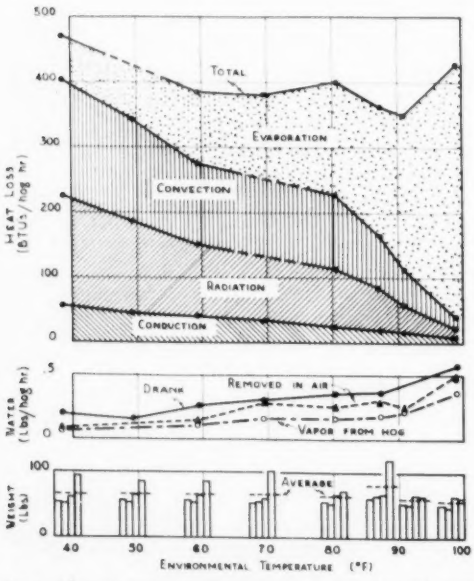

Fig 4. Effect of environmental temperature on heat loss and water relationships for an average hog of group A, weighing 58 to 81 lb during test period.

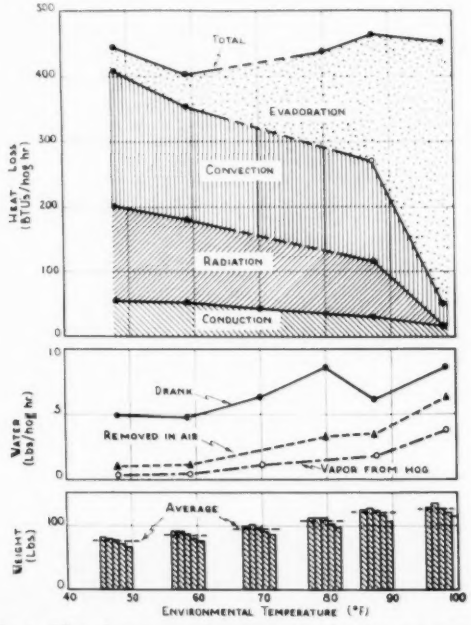

Fig 5. Effect of environmental temperature on heat loss and water relationships for an average hog of group B, weighing 75 to 125 lb during test period.

the chamber away from the drain. Most of the water drunk was eventually removed in the ventilating air. On the other hand, the animals of groups B and C urinated near the drain, and less of the amount drunk showed up in the ventilating air.

The weights of each animal at the time of the calorimeter tests are shown in the block diagrams in the bottom section of the figures. The animals of group A were not uniform in weight, one of the Durocs especially being larger than the others. This difference in weight somewhat affected the habits in the chamber as regards huddling, the big one being the "boss."

In Fig. 7 the percentage of the total heat lost by evaporation, and the average weight of each group, is shown for the different temperatures. The percentage for all groups decreased rapidly from a high of about 90 per cent at 100 F down to between 25 and 35 per cent at 75 F.

It is customary to compare heat losses on the basis of both unit weight and unit surface area. In our tests this is especially desirable because of the change in weight of the animals between various test periods; this variation was influenced by exceptionally rapid growth at the optimum temperatures, or loss of weight under the more rigorous environmental conditions. In the upper section of Fig. 8, the total heat loss per hundredweight is plotted for each group. The curves indicate clearly that the lighter animals lost heat at a considerably greater rate than the heavier hogs, per unit weight. It is evident that for every environmental temperature the relationship between heat loss per unit weight and total live weight is not constant.

There is less difference between the groups when they are considered on the basis of heat loss per unit area — as is also shown in Fig. 8 — since the surface area varies approximately with the two-thirds power of the live weight. In all cases, the lighter weight animals had a higher rate of heat loss per unit area than heavier hogs.

Heat and Moisture Loss from Sows and Litters. The heat and moisture loss of sows and their litters was studied in the chamber by bringing in the sows a few days prior to farrowing, and letting them raise their litters in the chamber for eight weeks, until weaning. To date, three sows, along with their litters, have been studied at constant environmental temperatures of 60, 70, and 80 F. The relative humidity in each case was maintained at about 50 per cent, and air velocity at 15 to 30 fpm. A Duroc sow with an initial weight of 382 lb was kept at the temperature of 60 F; she had 7 pigs through the first four weeks, 6 pigs through the fifth week, and 5 pigs during the remaining three weeks. A Berkshire sow, initially weighing 355 lb, was used for the 70 F period; she raised 8 pigs through the first three weeks and 4 pigs through the remainder of the period. For the 80 F run, a Poland China sow, initial weight 390 lb, was used; she raised 7 pigs from birth through the entire 8-week period.

The total heat loss from the sows and their litters is shown in the top section of Fig. 9. As would be expected, these total heat loss curves show a steady increase in total heat as the pig mass increases in the chamber.

For the temperature range of 60 to 80 F used in the tests, there was no apparent effect of environment on the heat loss of the sows and litters. This environmental effect may have been hidden by breed differences or variations in sow weight and litter sizes.

The average water consumption increased considerably following farrowing. At farrowing time the amount of water removal from the chamber was equal to or greater than the amount drank by the animals. After the farrowing period there was only the one point at which the water removed was greater than that consumed. This was in the case of PC-318 and may be related to the loss in body weight; she lost 30 lb due to farrowing and an additional 24 lb during the week following.

At the 80 F temperature the pigs seemed comfortable, at 70 F they shivered when standing by themselves, and at 60 F they never seemed to be warm enough. The sows seemed to be more comfortable at the lower temperatures. During the 8-week period after farrowing, the sows at the 60 and 70 F environments made weight gains, of 2 lb and 30 lb, respectively, whereas the sow at the 80 F environment lost 90 lb during this period. The latter sow raised the largest litter, however, both as to number and as to weight per pig.

Weekly observations of surface temperatures with a Hardy radiometer on sows PC-318 and D-127 and their litters indicated that, at 80 F, the pigs averaged 3 F warmer than the sow, and at 60 F, 10 F warmer. This greater surface temperature, together with the larger surface area per unit weight and greater physical activity, results in a much higher rate of sensible heat loss per unit weight for the pigs than for the sows. A need seems to be indicated for two separate environments

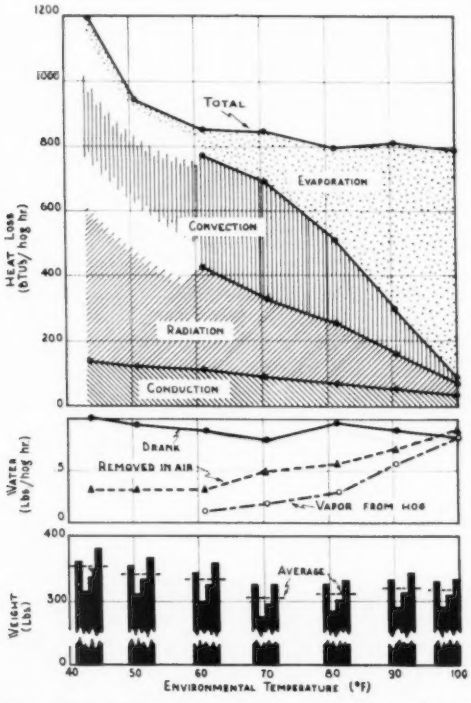

Fig. 6. Effect of environmental temperature on heat loss and water relationships for an average hog of group C, weighing 275 to 381 lb during the test period

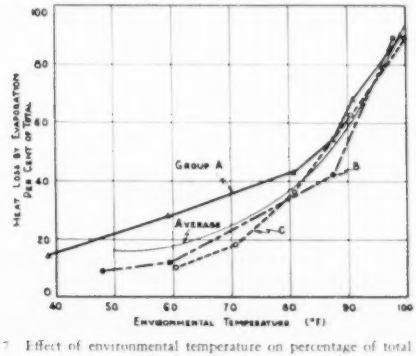

Fig. 7. Effect of environmental temperature on percentage of total heat lost by evaporation

in a hog farrowing house, one for the sow and one for litter.

Brody (8) has suggested that, per unit of surface area, the rate of heat lost by a pig increases from birth to a maximum rate at about 2 months of age, and thereafter declines. In our tests, at the end of the 8 week period, the surface area of the litter was equal to that of sow D-127 (60 F), slightly less in the case of B-1 (70 F), and almost twice that of the sow in the case of PC-318 (80 F). Although there was no means of separating the heat losses of the sows and the litters, to determine what part of this increase was contributed by the litter, it is evident that by the time the pigs are eight weeks old they are producing a greater percentage of the measured heat from the chamber, than is contributed by the sows.

Per unit weight, the total heat loss of sow and litter gradually increased, averaged about 200 Btu per hr per cwt over the eight week period (Fig. 9).

INTERPRETATION

Buildings for swine should be designed to provide the environment most conducive to rapid and economical growth of the animals. Heitman and Hughes (2) have shown that lightweight animals, 70 to 144 lb, make the cheapest growth at an environmental temperature of approximately 75 F, and heavyweight hogs, 166 to 260 lb, at about 60 F. Our tests were conducted with animals in the same general weight ranges, although the large animals were somewhat heavier.

Suppose the heat and moisture loss of hogs weighing 100 lb is desired at an environmental temperature of 75 F. Fig. 5 shows the heat loss at this temperature to be about 430 Btu per animal per hour. Of this amount, 30 per cent, or 129 Btu, is released as latent heat (Fig. 7), leaving 301 Btu as sensible heat. However, all this sensible heat cannot be depended upon to be available for supplying building and ventilation heat losses. Much of it will be used for evaporating liquids in the chamber at an expense of over 1000 Btu of sensible heat per pound of water removed. The central section of Fig. 5 gives us an estimate of what this expense might be. About 0.28 lb per hr is removed in the ventilating air, of which only 0.13 lb is vaporized as released by the animal, leaving 0.15 lb of water to be evaporated, under the conditions of our test, at the expense of the sensible heat. This amounts to 158 Btu (latent heat of evaporation 1051 Btu per lb), leaving only 143 Btu of sensible heat per hog per hour to take care of heat losses from the structure. For a 300-lb hog, at the same temperature, available sensible heat will be 311 Btu per hr. However, it has been pointed out, the optimum temperature for a 300-lb hog is considerably lower than 75 F. At 60 F a 300-lb hog will lose a total of about 860 Btu per hr, of which 750 Btu will be sensible heat, available for evaporating liquid and supplying building heat losses (Fig. 6). In our test, 0.30 lb of water was removed in the ventilating air per hour, only 0.08 lb of which was released by the animals as vapor. The remaining 0.22 lb of water was evaporated at an expense of 230 Btu per hr *to the sensible heat*. The remaining sensible heat, 550 Btu per hr, is available for supplying building heat losses, including ventilation.

The data presented in the curves apply to only a very small part of the pig "population." They illustrate the great variability of the heat loss from swine, even though the tests covered only a small segment of the possible arrangements of air temperature, temperature of surroundings, air velocities and pressures, and air relative humidity, that make up the environment. The results for total heat loss in our groups A and C are somewhat higher than the resting energy metabolism as measured by Brody (8), and somewhat lower than the heat loss from swine as calculated by Mitchell and Kelley (9), if the environmental temperatures at which these investigators did their work is assumed to be around 70 F. The 100-lb hogs of our group B lost slightly less heat than that determined by either Brody or Mitchell and Kelley. *(Continued on page 154)*

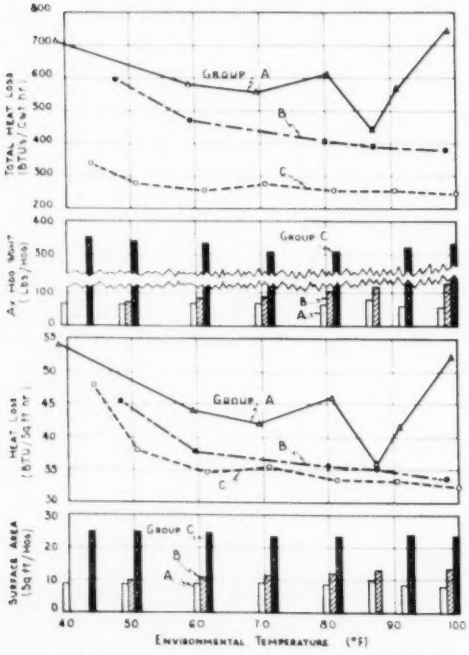

Fig. 8. Effect of environmental temperature upon total heat loss per hundredweight (upper section) and upon heat loss per square foot of animal surface area (third section from top). Average hog weight and surface area shown for each group.

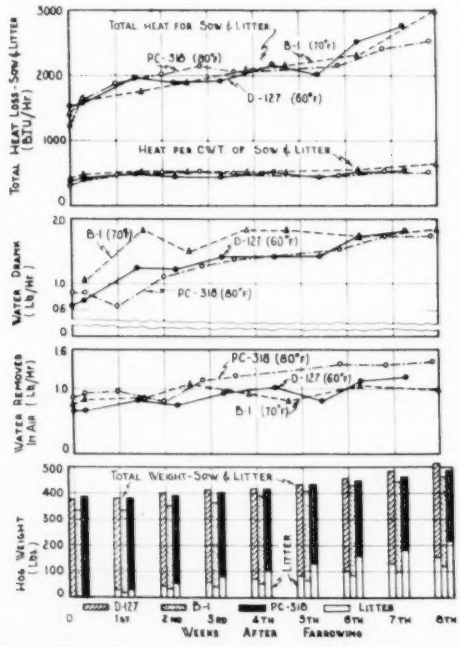

Fig. 9. Heat and moisture loss and water consumed by sows and their litters from farrowing to weaning eight weeks later. The weight of sows and litter is shown in the block diagram.

Cathodic Protection from Corrosion

By Joseph P. Collopy

IT HAS been estimated that the annual national loss due to corrosion is well over five billion dollars. This loss is distributed over the nation and found where steel or other corrosive metals are used. A large part of this loss occurs on farms, and in processing plants, power and irrigation systems, and other installations that pertain either directly or indirectly to the agricultural industry. Much of this loss could be prevented by a simple process known as cathodic protection.

Cathodic protection is the impressing of electromotive forces on a metal in an electrolyte by making the metal to be protected cathodic, in respect to the electrolyte. While considering a definition for cathodic protection, it might be well to consider the process that is going on when it is said that corrosion is taking place. Corrosion signifies destruction of metal by electrochemical or chemical action. The purely chemical action is of minor importance when corrosion is being considered from a practical standpoint.

When corrosion is taking place in an electrolyte, minute electric currents are flowing from some portion of the metal into the electrolyte and then back to some other portion of the metal. When these minute currents leave the metal, they carry small particles with them, and the metal is gradually wasted away. This process is illustrated in Fig. 1(A). Now if an anode with the proper potential is placed at a location so as to impress counter-electromotive forces sufficient to overcome the currents generated by corrosion, the action is stopped and an effective system of cathodic protection is provided. This action is illustrated in Fig. 1(B).

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author, JOSEPH P. COLLOPY, head, irrigation operations, Big Horn District, Bureau of Reclamation, U.S. Department of the Interior, Cody, Wyo.

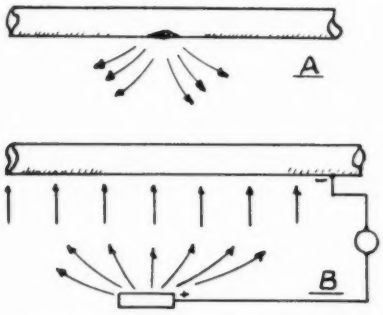

Fig. 1. These sketches show the theory of cathodic protection. A, local current from pitted spot on corroding pipe. B, cathodic protection current from an auxiliary anode.

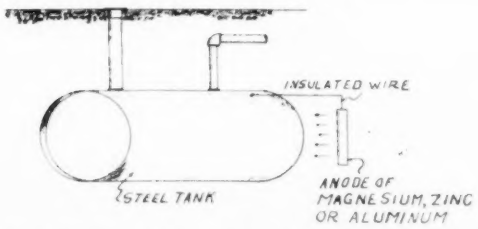

Fig. 2. This illustrates a well-established method of providing cathodic protection.

The theory upon which cathodic protection is based is quite simple. Why engineers have not done more with it is difficult to understand.

Source of Current. Direct current is required for cathodic protection. Alternating current is generally without effect for reasons that are apparent, if the elementary principles of the process are considered. The required potential is low, as is the current.

The source of potential may be generated direct current, rectified alternating current, or a galvanic cell or coupling of some kind. The large pipe-line companies in some areas use windmills driving small direct-current generators to secure protective power. A small rectifier attached to a commercial power line is a popular source of energy.

When an element like magnesium, zinc or aluminum is placed in water or a damp soil along with steel, for instance, a voltmeter connected across them will show a potential reading. The reading will depend upon the metals in the galvanic couple. The position of the metal in the electromotive-force series table will give an indication of this potential difference. Polarization and other factors enter into the actual reading secured.

If an anode is placed as indicated in Fig. 2 a primary cell is set up similar to a dry cell. Installations similar to the one shown in Fig. 2 is a well-established method of providing cathodic protection. The amount of protective current furnished may be checked by inserting a milliammeter in the insulated wire lead.

The galvanic anode can be used on various types of installations. Just when a galvanic anode or one with generated potential should be used is a problem for the cathodic engineer. In general, it can be said that for an isolated structure the galvanic anode would be favored, but for a large complicated layout, with a commercial power circuit available, the anode supplied with external power may be the most desirable. A cathodic protection layout using one anode powered by an a-c rectifier is shown in Fig. 3.

Cathodic Protection for Farmstead. There is no limit to the type of equipment that can be given cathodic protection and new designs are being worked out almost daily. A large number of the installations are being made in processing plants handling farm products or in plants turning out products for farm use. Many of them are being applied to equipment about the farm home such as furnaces, hot water heaters, pumps and the like. One example is providing cathodic protection for an ordinary hot water tank. A magnesium rod is fastened to a special pipe plug and secured into place. When

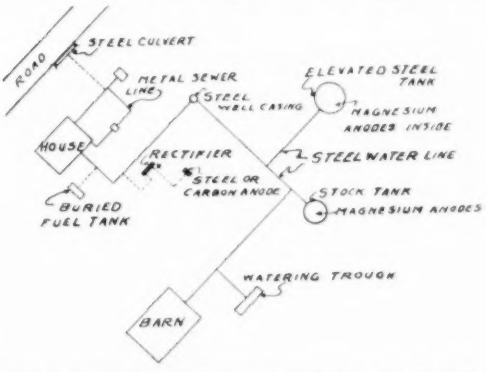

Fig. 3. A cathodic protection layout for a farmstead using one anode powered by an a-c rectifier.

the rod is depleted, it can easily be replaced, and the hot water tank can thereby be kept in use for an indefinite period.

Following is a partial list of items around an ordinary farmstead, the life of which can be greatly extended by the use of cathodic protection: Steel water lines, cast-iron sewer lines, well casings, steel culverts, steel storage tanks (elevated and underground), the inside and bottoms of stock watering tanks, culverts, grease traps, steel septic tanks, hot water heaters, and steam and hot water furnaces.

Savings Possible. Cathodic protection is not a cure-all. For instance, today it cannot be used for the protection of the inner surfaces of long small-diameter pipes. It can be used only for buried or submerged surfaces, and will not prevent corrosion brought about by a spray or a moist atmosphere. It is not intended to take the place of painting or other similar protective coatings. New installations where cathodic protection is used should be given a good insulating covering. This coating will greatly reduce the required cathodic current. However, the induced protection will take care of the small pin-point areas that are apt to be uncovered from the beginning and will gradually increase the protection as the covering depreciates.

The cost of installing cathodic protection is low. The large pipe line companies estimate that they save $8 to $10 for every dollar invested in cathodic protection. The cost of the galvanic anodes and commercial power is low. The cost of magnesium anodes is approximately 40c to $1 per lb, and with average efficiency will produce 500 amp-hr per lb. As the required current may be estimated at 2 ma per sq ft, one pound under average condition will protect one square foot of outside pipe surface for more than 28 years. If magnesium can be secured from crashed bomber wheels or similar sources, the cost may be somewhat lower.

When power is applied to the anodes, the cost per kilowatt-hour is practically the only cost that need be considered after the installation is completed, as any scrap steel such as old steel rails or long-life carbon units may be used. The voltage required for such an installation can be determined experimentally using variable source of direct current such as an arc welder, but as a rough check 20 v and 2 ma per sq ft will do for power-estimating purposes. The power cost is so low that a little variation one way or the other makes little difference.

If in doubt as to the efficiency of an installation, a small polished steel plate can be welded to the steel to be protected and the appearance of any corrosion noted. A coating of salts or ionized iron oxide particles should not be confused with corrosion.

Corrosion is aiding in the depletion of our available rough material; valuable man power is being used to build and replace that which it destroys; large quantities of extra metal is being constantly designed into all types of equipment in order to compensate for this tearing-down process, and at the same time the output for our farms, factories and power plants is reduced. Any intelligent effort toward the reduction of corrosion in equipment used for agricultural operations generally pays high in dividends. It would seem that cathodic protection is a wide-open field for the agricultural engineer.

Heat and Moisture Loss from Swine

(Continued from page 152)

Discussing moisture production by the animals, Mitchell and Kelley (9) estimated that 25 per cent of the total heat lost by the animal is in the form of latent heat. The present tests at California indicate that this percentage is average at 70 F. At 70 F about twice as much water was removed in the ventilating air as was produced in the form of latent heat, a considerably higher figure than was anticipated by Miller, Ashby and Zeller (10). It should be noted that a large part of the water drunk by the animals was eventually removed from the chamber in the ventilating air. The use of bedding, arrangements of drains or gutters, the methods of barn cleaning, and the type of waterers used, will certainly affect the amount of free water evaporated, as well as the amount of sensible heat left for heating the building.

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Erosion Control in Engineering Works

By Louis J. Goodman

PURSUANT with efforts to combat erosion of certain airfields and ammunition depots, this paper summarizes 8½ months of research on hydromechanical studies of soil erosion processes. In these studies additives have been used to reduce the detachability of the soils when exposed to the blast of falling raindrops.

Devices simulating rainfall were investigated and a suitable apparatus was made for use in the laboratory phase of this project. Soil samples taken from various parts of the country were treated with a number of different chemical additives, applied by different methods, and then subjected to the erosive actions of artificial rain. Based on these studies, and on results from supplemental observations made on outdoor test plots, two practical methods of application were evolved:

1 Sprinkle chemical on surface uniformly and wet down.

2 Rake in chemical to a depth of ½ to ¾ in and wet down. Of these two methods, the surface treatment has been the more effective.

As a check on the laboratory work, field slopes have been set up in several sections of the country and observations on these have been very encouraging.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1951, as a contribution of the Soil and Water division. The work reported in this paper was supported in part by a contract between the Bureau of Yards and Docks of the U.S. Department of the Navy and the Ohio State University Research Foundation.

The author: LOUIS J. GOODMAN, assistant professor of civil engineering, Ohio State University, Columbus, Ohio.

ACKNOWLEDGMENTS: The author, who is project supervisor, expresses his appreciation to George E. Large, head, civil engineering department and C. E. MacQuigg, dean, college of engineering, Ohio State University; to W. D. Ellison, soil conservationist, Bureau of Yards and Docks, U.S. Navy, and to the representatives of the research department of Monsanto Chemical Company for their cooperation. Recognition is also given to William G. Colter and T. P. Craig, research assistants on the project.

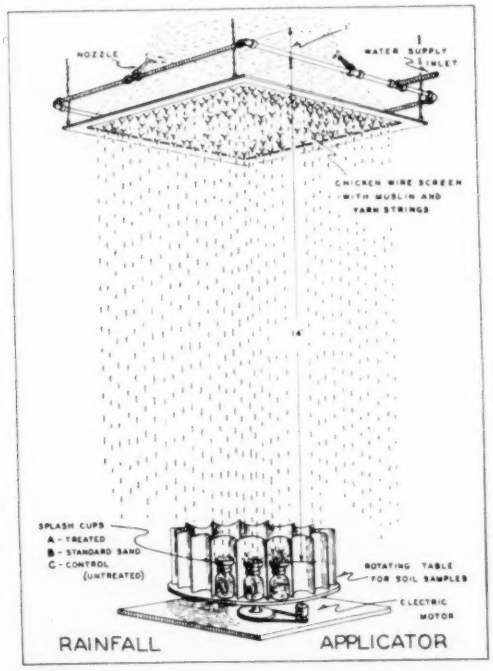

Fig. 1 The artificial rainfall applicator used in the study reported in the accompanying paper

Introduction. One of the more urgent problems in the engineering world today exists in the field of soil erosion control. For many years, engineers and other soil conservationists have attempted to cope with this costly problem by the following methods:

1 Use of various soil stabilizers. To date many of these have been shown to be too expensive, temporary in effectiveness or detrimental to vegetation.

2 Use of flatter slopes. This involves the moving of large quantities of soil and is costly. Also, in many cases, much needed space would be necessarily wasted.

3 Erection of retaining walls. This will prevent soil loss from the area but not local erosion. The method is expensive.

Because of the U.S. Navy's interest in curbing soil erosion*, the present research study was initiated for the purpose of making hydromechanical studies of soil erosion and for exploring techniques for controlling the construction of slopes. Important parts of the over-all objective are as follows:

1 Reduce drastically the damaging effects of rainfall on steep slopes (1 on 1½, and 1 on 2).

2 Resist leaching and fertility erosion for 1 to 2 years. It was felt that this would afford sufficient time to establish a completely effective vegetal cover.

3 Be conducive to plant life.

Equipment. In order to study the detaching effects produced by raindrops, an artificial rainfall applicator was designed and constructed. Certain factors of the equipment used by W. D. Ellison† and W. H. Pomerene were incorporated into the final design (Fig. 1). The frame containing the nozzles consists of ¾-in pipe fitted in a closed circuit to form a 5-foot-square frame, with a garden nozzle fitted at the midpoint of each side. The four nozzles emit a fine spray which falls onto a drip screen. This drip screen is made of chicken wire which is covered with muslin and has a yarn string about 1½ in long hanging from each depression. The screen is suspended by wires approximately one foot below the pipe and nozzles. The yarn absorbs the water as it falls on the screen and emits it in a series of drops from the tips onto the samples which are placed on a rotating table. The use of a rotating table and the practice of oscillating the screen ensures identical rainfall treatment on all soil samples.

For determining the splash loss of a given soil, splash cups were constructed (three such splash cups may be seen in place on the rotating table in Fig. 1). The cups consist of a 3½-in-diameter metal cylinder 1-3/10 in deep. To the bottom of the cylinder a ¾-in deep cone was soldered. The tip of the cone has a ½-in opening to permit the insertion of a cotton wick and to allow for the escape of water due to the rainfall. The threaded metal ring of an ordinary two-piece fruit jar lid was then soldered to the splash cup. The jar serves a dual purpose: (1) it holds water for saturating the soil sample via the cotton wick (saturation brings the soil to a standard condition of moisture for the test and when used in natural rainstorms it will prevent the soil from blowing out of the cup between rains), and (2) it collects the water that seeps down through the soil during the splash test.

It is desirable to use an oilcloth large enough to cover all

*The U.S. Navy controls nearly 4,500,000 acres of land ranging from barren desert to heavily timbered areas. This includes shore installations such as airfield and ammunition depots.

†Ellison, W. D., and Pomerene, W. H.: "A Rainfall Applicator," AGRICULTURAL ENGINEERING (June, 1944).

the samples until the rainfall applicator is functioning properly. When everything is ready, the cloth is pulled out quickly in order to start the "rain" on all samples at once. Also, upon completion of a test, the samples should again be covered quickly until all dripping has ceased.

Rainfall intensity can be controlled by decreasing or increasing spray pressure, or by the use of some or all of the four nozzles. The intensities used at Ohio State University to date varied from 8 to 12 iph.

Raindrop diameter is controlled by the size of the chicken wire opening and by the diameter of the yarn. Employing a 8-16 in-diameter cotton yarn with a 2-in mesh wire produced a drop of 5.04 mm diameter. This compares favorably with the size of drop encountered in the violent storms which comprise the erosive rains.

Raindrop velocity is controlled by the height of fall. Since a 14-ft fall, which appears to give 80 + per cent terminal velocity, had been used in previous studies in raindrops, it was decided to adopt this height as a check on former analyses.

Polymer Additives. In addition to the development of the apparatus, the second major problem concerned the finding of an additive which would show promise in reducing splash erosion and still not be detrimental to vegetation. The odds against finding such an additive appeared to be insurmountable since the majority of chemical additives available had been developed to attempt to stabilize soils from a solidification aspect. Most of these would not permit the planting of a vegetative cover, which is the permanent solution to the erosion problem. Also, the treatment in most cases was too expensive for large areas.

The Monsanto Chemical Co., which had been studying on an experimental basis a number of different water-soluble polymers for the control of water and wind erosion, learned of the U.S. Navy's interest in curbing erosion. Representatives of Monsanto brought to the project four water-soluble polymers that had remarkable effects in drastically altering the structure of soils containing clay particles. These materials are also very effective not only in flocculating clay suspensions, but also in altering the physical character of the precipitate, i.e., state of aggregation and filterability. It is important that even though these polymers as prepared are water soluble, when applied to a clay soil or clay suspension either as a powder or from an aqueous solution, they are absorbed on the individual clay particles by exceedingly powerful forces of attraction and are exceedingly difficult to leach out of the soil with water.

As shown in the accompanying tabulation, the polymer samples comprise four principal chemical categories each of which offers certain unique properties and varies somewhat in the nature of the effect produced. The first three families are hydrophilic in character while the fourth family is more hydrophobic‡. The addition of any of the additives to a soil revealed a remarkable ability to raise the plastic limit and the water holding capacity of the soil. This was shown in a simple test in which a mire was made of water and soil containing clay. When a very small concentration of any one of the additives was sprinkled into this slurry, the water was taken up and the fine grains of the soil formed into aggregations or clumps.

The stability of the aggregates in water can be shown in a very simple manner. If soil crumbs which are not stable in water are treated, and then both treated and untreated crumbs are placed in a beaker of water, the untreated soils immediately disintegrate and form a slurry. The treated crumbs, however, show no such disintegration and maintain their shapes indefinitely.

Laboratory Investigations. Soil erosion is defined as "a process of detachment and transportation of soil materials by erosive agents"**. From this definition it appears that the primary solution to the erosion problem on steep slopes must lie in the prevention of the detachment of particles of soil. Certainly very little can be done in the way of preventing transportation of detached particles on steep cuts and fills which have no vegetal cover.

Since the principal detaching agent is the raindrop, it was decided to run a sufficiently large number of splash tests to determine the effectiveness of polymer additives in reducing the splash loss of soils subjected to high erosional damage††. To establish a trend on the use of these additives, graduation analyses were run on soil samples treated with 0.2, 0.4 and 0.6 per cent‡‡ (by dry weight) of each chemical. The treatment consisted of thoroughly mixing the additive into the dry soil. Enough water was then supplied to put the additive into solution and the sample was then oven-dried at a moderate temperature. The 0.2 per cent concentration gave results comparable to the 0.4 and 0.6 per cent concentrations and was adopted for use in the preliminary splash tests. It is of interest to note here that the above results, when compared to mechanical analyses on the untreated soil samples, showed that the percentage of soil passing the No. 200 sieve was reduced to one-half.

Following the same manner of treatment used in the mechanical analyses, splash cups were prepared with a sandy silt soil containing some clay sizes. The sample, as in all succeeding tests, was compacted into the cup in such a fashion as to give a density comparable to the "in situ" density.

A preliminary splash test was conducted for 30 min at a turntable speed of 4 rpm and a rainfall intensity of 5½ iph. From this test it was decided that the additives might prove more effective if applied by some other method. After many splash tests using various methods of treating the soil, it was

‡Hydrophilic, having strong affinity for water; hydrophobic, lacking strong affinity for water.

**W. D. Ellison "Soil Detachment and Transportation," U.S. Soil Conservation Service "Soil Conservation," February, 1946, vol. II, no. 8.

††These soils are principally fine sands, silts, clays, or any combination thereof.

‡‡These percentages were recommended by Monsanto Chemical Co.

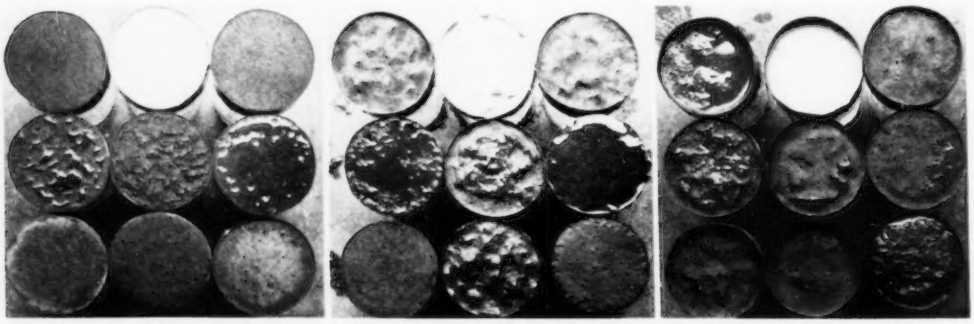

FIG. 2. These pictures show some effects of rainfall duration on splash loss of both untreated and treated samples of a silty soil: *(left)* start of test, *(center)* 5-min duration, and *(right)* 30-min duration.

Family No	I HYDROPHILIC CRD-186	II HYDROPHILIC CRD-195	III HYDROPHILIC CRD-189	IV HYDROPHOBIC CRD-197
Rate of solu in water	Slowly soluble (acid and salts rapid)	Very slowly soluble	Salts rapid	Rapid
Stability to acids	Gels slowly (by hydrolysis)	No change	Immediate precipitation	Immediate precipitation
Excess Ca + +				
Al + + +	Precipitates	Precipitates	Precipitates	Precipitates
Particle size	Coarse (salts fine)	Fine	Fine	Fine
Effect of formaldehyde	None	None	Gels with HCHO	None

CRD-186, calcium carboxylate polymer; CRD-189, the sodium salt of hydrolyzed polyacrylonitrile; CRD-195 and CRD-197, same type as CRD-186 (Through the courtesy of the Monsanto Chemical Co.)

decided to eliminate all except the two referred to at the beginning of this report. In later laboratory tests, chemical treatment of soil by these two methods reduced splash loss by as much as fifteen times.

Data and results of a typical splash test using additives CRD-186 and CRD-189 are shown in Table 1. The soil investigated was a highly plastic clay containing some silt and well-graded sand. It can be observed from this table that using CRD-189 as a surface treatment produced excellent results, reducing the splash loss by ten times. In the other hand, CRD-189 when raked in to the soil gave very poor results. CRD-186 produced good results as a surface treatment and fair results when raked in. The standard sand used was adopted by W. D. Ellison for the mathematical analyses of detachability***.

A series of photographs was taken to illustrate some effects of rainfall duration on splash loss of both untreated and treated samples of a silty soil. Three photographs (Fig. 2) show the effect for time intervals of 0, 5, and 30 min.

The effects of the additives on the plastic limit, the liquid limit, and the permeability of various soil samples are currently being investigated. On the basis of inconclusive data at this writing the additives, as a group, tend to increase the plasticity limits and the permeability. CRD-186 (in family I) is noticeably effective in increasing the permeability.

Laboratory tests on model slopes of varying degree, using both untreated and treated soil samples, have been carried out under rainfall applications of high intensity. It is hoped that further work along these lines may be done in the future. Based on splash analyses from the model slopes and from the splash cups, an attempt is being made to arrive at a mathematical relationship between the energy of raindrops and the detachability of soil particles.

Field Slopes. Test plots have been established in several sections of the country to obtain field correlations with the laboratory results. At the U.S. Naval Ammunition Depot, Earle, N. J., slopes of 1 on 2 (1 vertical to 2 horizontal) and 60 ft long have been selected for field testing the polymers. Results have been very encouraging in this area.

***Ellison, W. D. "Soil Erosion Studies — Part II," AGRICULTURAL ENGINEERING (May, 1947).

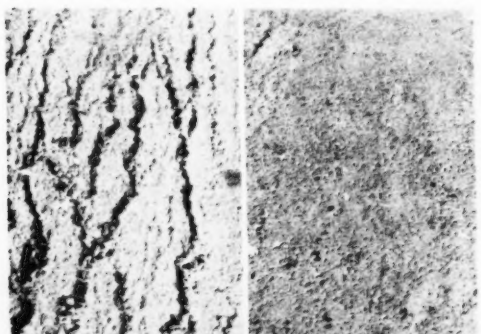

Fig. 3 *(Left)* A control (untreated) slope. *(Right)* A slope treated with CRD-189 (surface treatment) after several highly erosive rainstorms

TABLE 1. SPLASH ANALYSIS

All soil passing a No. 14 screen; rainfall intensity, 6 15/16 iph; duration of test, 20 min; fall, 14 ft

Jar No.	Material*	Method	Samples before test: Wt. of dry material g	Samples after test: Tare wt., g	Tare + oven dry wt., g	Splash loss	Per cent loss of orig. wt
1	Pa.	Control	300.00	124.1	357.4	66.7	22.2
2	Pa.	Control	300.00	130.8	361.8	69.0	23.0
3	S.S.	—	575.00	163.1	425.9	112.2	29.9
4	S.S.	—	575.00	162.2	416.0	121.2	32.3
		Surface treatment (0.35 g of additive by dry wt.)					
5	Pa.	186	300.35	168.5	458.0	10.7	3.6
6	Pa.	186	300.35	177.2	458.1	19.5	6.5
7	Pa.	189	300.35	157.5	451.6	6.3	2.1
8	Pa.	189	300.35	161.9	455.0	7.3	2.4
		Rake-in treatment (0.2% of additive by dry wt.)					
9	Pa.	186	300.60	170.3	436.0	34.9	11.6
10	Pa.	186	300.60	162.5	427.4	35.7	11.9
11	Pa.	189	300.60	179.9	568.4	112.1	37.2
12	Pa.	189	300.60	156.6	543.1	114.1	38.0

*Pa. denotes Mechanicsburg, Pa., soil; S.S. denotes standard sand (60-70 gradation).

Fig. 3 shows a control (untreated) slope and a slope treated with CRD-189 (surface treatment) after several highly erosive rainstorms. The control slope was severely eroded whereas the treated slope shows no sign of erosion. These slopes, which are 1 on 2, are located in a highway fill section in the Blendon Woods Metropolitan Park area, Columbus, Ohio.

SUMMARY

1 A group of chemicals have been listed which have performed satisfactorily. However, it has been noticed that CRD-189, the most effective when applied as a surface treatment, is not effective when raked in the soil. This may be due to the fact that it produces a bulking effect, causing much splash loss.

2 From data obtained on most soils investigated in the field, CRD-189 with surface treatments seems most effective.

3 Two practical methods of applying the chemicals to soil plots have been determined: (a) sprinkle evenly on surface and (b) rake in to approximately ¼-in depth. NOTE: In both methods wet down thoroughly but avoid runoff.

4 Low weight concentrations of the chemical are extremely effective in reducing splash loss. Recommended concentrations as of this writing are as follows: (a) ¼ — 1 lb per 100 sq ft for the surface treatment; (b) ¾ — 1½ lb per 100 sq ft for the rake-in treatment.

5 The polymer additives at economical concentrations do not inhibit the growth of vegetation. This is substantiated by developments at the test slopes established at Earle, N. J., and elsewhere.

6 Based on the many splash tests run to this date, it appears that there is a possibility of eventually setting up a chart to tell the amounts of additives to use on each different soil and slope.

7 It appears that the chemicals may also prove extremely effective as dust controllers.

8 Since silty soils are susceptible to frost heave and because the additives bond the fine-grained particles into larger aggregates, it seems advisable to study the effects of these additives in controlling frost action.

9 Cut and fill sections will tolerate steeper slopes when treated with these chemicals.

Bulk Drying and Storage of Rice on the Farm

By H. T. Barr and L. G. Coonrod
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RICE production in the United States is confined primarily to California, Arkansas, Texas and Louisiana. In 1950, 1,650,459 acres were devoted to rice in these states, producing 57,581,636 cwt. In cash crop, rice stands second in Arkansas, third in Louisiana, fourth in Texas, and produces about 27 per cent of the cash income for the five California counties where some 85 per cent of the California rice is produced.

California with a production of 7,772,000 cwt in 1950 stored 50 per cent of its seed rice and 50 per cent of the milling rice on the farm. Texas produced 10,878,500 cwt in 1950, using commercial storage practically entirely. Louisiana produced 10,782,000 cwt in 1950, storing 50 per cent of its seed rice and 15 per cent of the milling rice on the farm. Arkansas produced 7,975,000 cwt and stored approximately 25 per cent on the farm.

Previous to the widespread use of the combine and rice driers, all the rice was cut with binders, shocked until cured, threshed and sacked. If the market was satisfactory, the rice was sold, but if a farmer preferred to keep his rice for future sale, storing the rice was only a matter of taking it to a commercial warehouse or storing it in his own warehouse. There was ample storage for sack rice. The shift from binder to combines was not orderly, as it was almost an overnight change and the many related problems such as drying and bulk storage had to more or less become stepchildren to the combine.

There is no doubt that the percentages of rice under loan and purchase agreement would have been much larger if bulk-storage facilities had been available on the farm. The size of the farm and whether the farmer is a landowner or tenant is found to be a major consideration in the question of farm storage. The California operations are mostly large farms with storage in concrete, elevator-type structures. Up to the present time many of the California farmers stored for a very short time, one day to one week in bulk, then sacked and stored in flat storage. The recent destruction of the largest source of sacks on the Pacific Coast, war demands for sacks, and the marked increase in sack prices is causing many California farmers to become interested in the 1000 to 3200-bu flat-bottom steel bins. At the other extreme, in Louisiana with 7065 rice farmers, 69 per cent have 50 acres or less in rice, 16.8 per cent have over 100 acres in rice, and of this latter only 15 farms have over 1000 acres in rice.

The average capacity of the California concrete bin is 7000 cwt, of which there are 72 plants in the state. Texas has 18 bulk and 57 sack storage units as listed by PMA, with none of these listed as being on the farm. The Texas commercial storage capacity is listed as close to 6,000,000 bbl, with public storage representing 5,485,500 bbl, but only 686,000 bbl of this is bulk storage. Terminal elevator storage suited to the needs of the quantity handlers of rough rice reduces this latter by 194,000 bbl. Thus only 492,000 bbl of public bulk storage, about 8 per cent of the Texas 1950 crop, is available to handle the average grower's crop in bulk. Formerly the Texas rice was sacked as threshed, but today practically all Texas rice is combined. Sacking is no longer part of the production phase, but lack of bulk-storage facilities forces most of the producers to sack any rough rice they wish to hold. The most serious need in Texas would seem to be to increase the bulk-storage space so as to allow the present driers to empty their working bins readily, to prevent slowdowns and shutdowns and to get more rice dried with present driers.

The situation in the other three states will no doubt parallel that of Louisiana where 40 per cent of the crop in 1950 was harvested in two weeks and the present drier and bulk-storage facilities are not adequate to handle this volume of rice in the short period. This overcrowding of available facilities has resulted in depressing the price of rice and and lowering the milling quality of the grain. The lack of sufficient farm drying and storage in Louisiana for both the 1949 and 1950 crops resulted in many sales of freshly combined rice at $1.00 and $3.50 per barrel under the market price for that day. Spreading the harvest season by planting at different dates and using good varieties that mature at different dates are each good stopgap measures. Factors tending to minimize the spread are the rainy season, and the fact that certain varieties have much better combining and drying characteristics than others, are more in demand and bring a higher market price. The miller or elevator man who bought at a depressed price of $3.50 per barrel may have been gouging the farmer, yet on the other hand, with an elevator already filled to almost overflowing, he was taking a risk in adding more rice that must be partially dried in the next few hours. For a small farmer, on the other hand, who only has a yield of 500 bbl (1800 bu) a depression of $1.00 per barrel would wipe out most of his profit, and $3.50 per barrel would be disastrous.

Some form of storage to hold the rice in good condition until it can be dried, and thus utilize the present drier capacity over a longer period of time, is the aim of several commercial and technical people as well as farmers.

The storage of rice and keeping it in prime condition has always been a problem due to the warm climate and high humidities in the southern states. Commercial warehouses and mills in each of the four states have a practice of turning the rice every 20 to 30 days. The moving of the rice from one bin to another provides a certain amount of aeration. In some installations the rice is passed through the drier (with the heat turned off) to give additional aeration. A few large elevators equipped with adequate aeration systems are finding that it is not necessary to move rice each 20 to 30 days, or perhaps not at all.

Where rice is combined and stored on the farm, the farmer through necessity will have to own his drier or transport the rice to a commercial drier and have it dried before storing. If the farm storage has some form of aeration system and a careful check is kept of the temperature of the rice, moisture content, and insects, there should be no deterioration in the quality of the rice. Farmers having aeration systems have found that there are a lot of factors to be considered in using such a system. No foolproof formula has as yet been worked out for an aeration system.

The charges for storage in commercial and cooperative warehouses varied between the different states. California reporting $2.25 per ton for sack rice and $2.75 per ton for bulk rice; Texas $4.32 to $4.94 per ton for sack storage plus a receiving and loading out charge; Louisiana $4.30 to $4.90 per ton for sack and $2.60 to $3.10 for bulk rice. In Arkansas the only report was for rather large quantities of CCC rice with rates being negotiated for each warehouse. In each state the charge for storage only could be broken down somewhat as follows: $1.85 per ton for the first month, $1.23 per ton for the second month, $0.74 per ton for the third month, $0.50 per ton for the fourth month and no added charge for the balance of the year. One (Continued on page 160)

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at Houston, Tex., June, 1951, as a contribution of the Farm Structures Division.

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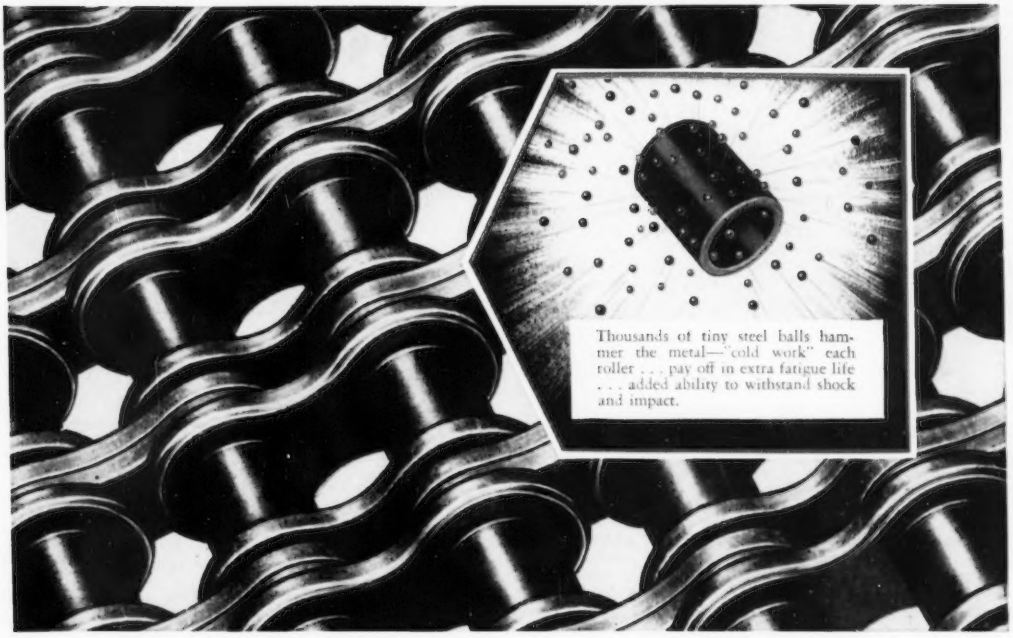
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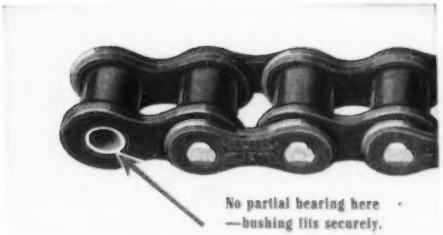

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Bulk Drying and Storage of Rice

(Continued from page 158)

Louisiana cooperative in 1950 charged by the bin per month in storage to four months and no added charge for the balance of the season. With 63 steel bins of 330-bbl capacity, 18 concrete bins of 750-bbl capacity, and 15 concrete bins of 1500-bbl capacity, each owner was allowed to keep his rice separate and obtain a rate between $2.60 and $3.10 per ton for the season, if his bin was filled to capacity.

Research data accumulated in Louisiana with the 1949 and 1950 rice crop shows that rice containing more than 14½ per cent moisture cannot be safely stored. Periodic inspection and fumigation will control insects for storage of nine or ten-month periods and perhaps longer. No appreciable difference can be noted at this time as to the type of material of which the bin is manufactured and its effect upon the keeping quality of the rice. It is planned to hold several lots of rice of 500 and 1000 bu in bins made from welded steel, bolted galvanized iron, wood, and concrete staves for up to two years. Rice has now been in these bins for 8 mo and is in excellent condition, with weekly inspections and monthly tests being made.

Studies of temporary storage of undried rice were made in a glass-lined bin that can be hermetically sealed, and in two 500-bbl galvanized iron bins in which an aeration system had been installed. Rexoro rice, 260 bbl, with a moisture content of 18.1 per cent moisture direct from the combine, was stored in the glass-lined bin on November 10, 1949. Temperature readings at 10 points in the bin were recorded daily to June 12, 1950. The glass-lined bin was again filled with 360 bbl of Zenith rice with a moisture content of 19.3 per cent direct from the combine on October 4, 1950, and was opened November 9, 1950. The rice did not heat to a critical point (91 F being highest) during the storage of either lot; however, air temperatures as high as 95 to 102 F were recorded in the air space above the grain. The carbon dioxide content of the air increased rapidly during the first 24 hr after the bin was sealed (Table 1). The bin was not equipped for taking

TABLE 1. Data Showing Carbon Dioxide Content of the Air in the Glass Lined Bin During Storage of Rice from the 1950 Crop

Date	Time	Location and per cent carbon dioxide			
		1	2	3	4
10/4/50	7:45 a.m.	7.2	18.8	7.0	—
10/4/50	5:00 p.m.	2.4	19.8	14.0	2.0
10/5/50	8:00 a.m.	19.0	23.0*	22.0*	7.4
10/5/50	4:30 p.m.	12.0	22.2*	22.5*	11.2
10/6/50	8:00 a.m.	21.2	23.0*	24.0*	17.0
10/7/50	8:00 a.m.	24.0*	25.0*	25.0*	22.5*
11/6/50	11:00 a.m.	All above scales of 21.5 per cent			

CO_2 tap number	Location
1	Bottom of barrel, 3 in from side
2	Bottom of barrel, center
3	Middle of barrel, center
4	Air above rice

†Bin opened at 7:45 a.m. to finish filling bin.

*Estimated reading.

carbon dioxide samples the first year. The aerobic organisms present, free fatty acids, and milling quality are shown in Tables 2, 3, and 4 and will be passed over here briefly, except to say that the free fatty acids in the bran are 6 to 7 per cent higher than is normally found in freshly milled bran from sound rough rice. An objectionable odor was noticed each time the bin was opened, but this odor was more pronounced after the long period of storage, and indications are that the odor can be removed. Germination of the rice was very low after storage of both lots. The milling quality and grade was not altered for the short storage and only slightly on the long storage. However, the first year the buyers were afraid of the slightly sour odor.

TABLE 2. Data Showing Moisture, pH, Microbiological and Germination on 1949 Crop (Rexoro Rough Rice Stored 7 Months in Sealed Glass-Lined Bin)

Sample	Depth in bin, ft	Per cent moisture	pH	Aerobic organisms*				
				Viable bacteria per g	Viable yeast and yeast-like organisms per g	Molds per g	Organisms growing under anaerobiosis*	Per cent seed germinating, 14 days
				x 10³	x 10³		x 10³	
1	top	16.2	7.0	9,200	1,070	600	thousands	0
2	1 ft	19.0	6.7	5,200	2,245	10	thousands	0
4	2½ ft	18.1	6.8	345	88	10	145	0
6	5½ ft	17.3	6.9	31	2	10	21	3
7	10 ft	18.5	6.9	230	12	10	70	0
8	bottom	18.6	6.9	259	18	10	120	2

*Fifth day of incubation.

TABLE 3. Data Showing Percentages of Free Fatty Acids, Lipides, Moisture, and Nitrogen in the Bran of 1949 Crop (Rexoro Rough Rice Stored 7 Months in a Sealed Glass-Lined Bin and Dried in a Commercial Drier*)

Sample	Free fatty acids, per cent	Lipides, per cent	Moisture, per cent	Nitrogen, per cent
A	9.26	24.39	10.29	2.46
B	9.24	24.35	10.27	2.48

*Analyses made August 15 by analytical and physical chemistry division, SRRL.

Note: The free fatty acids in the bran are 6 to 7 per cent higher than is normally found in freshly milled bran from sound rough rice

Part of the second lot of rice after being dried in the LSU-type continuous drier was returned to the glass-lined bin and sealed for further study. The rice is still in the bin in apparently the same condition as sealed. A drier capable of handling the daily capacity of 1 to 5 combines or the rice crop of several cooperating farmers, is a proven success.

TABLE 4. Data Showing Milling Quality, Fat Acidity Value, Germination, and Grade of 1949 Crop Rice Stored in Glass-Lined Bin

Tests	Air dried original (composite)	Air dried as taken from bin (composite)	Entire lot as milled
Milling quality	81-111	66-111	65-107
Fat acidity value	13	64	—
Germination	—	18.5%	—
Grade	1	Sample*	—

*Sample grade on account of sour odor.

Most operators and authorities are not in too close agreement as to the maximum dry air temperature to use for best milling quality. The upper safe limit is probably 130 F for the dry air temperature. The rice grain should not be heated above 110 F for maximum milling quality and some incomplete tests have tended to indicate a better milling where the rice grain was not heated above 105 F. The proper air temperatures to use are governed to a certain extent by the variety; moisture content at harvest, air temperatures and relative humidity. Probably the best guide to use in connection with drying is "Recommended Drying Air Temperatures for Drying Rough Rice in Rice Dryers," by W. D. Smith, rice supervisor, Production and Marketing Administration, USDA, New Orleans, La. A condensed recommendation from this publication is as follows:

Atmospheric conditions	Safe drying temperature (F) when rice moisture content is:	
	Less than 16.1 per cent	More than 18.8 per cent
Temp, 60-70 F, R.H., 30-50 per cent	101-104	116-119
Temp, 60-70 F, R.H., above 85 per cent	105-108	121-123
Temp, 90-99 F, R.H. 50-60 per cent	108-112	123-127
Temp, 90-99 F, R.H., above 85 per cent	113-118	128-133

(Continued on page 162)

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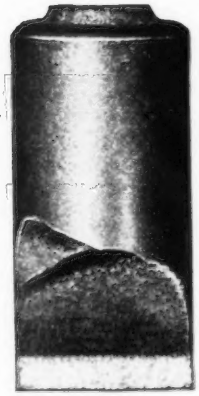

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During the past fifty-five years we have watched many ambitious and enterprising manufacturers endeavor to copy the very extensive Oberdorfer line of bronze rotary gear pumps or present the world with their substitute.

It was not our business to notify these gentlemen that it would be financial suicide to try to duplicate the combination of quality and price so long associated with the name of Oberdorfer thruout the world. History is amply littered with the evidence.

There are available today many spray pumps more intricately designed, more delicately constructed and more costly to purchase and operate in the field.

Why gild the lily! Demand an inexpensive, trouble free corrosive resistant bronze gear pump that accurately meters your spray formulations, positively, efficiently and at lowest cost per acre.

BUY *Oberdorfer*

Agricultural Pump Div., Oberdorfer Foundries, Inc.
1423 Thompson Rd., Syracuse, N. Y.

BRONZE OBERDORFER SPRAYING PUMPS

Bulk Drying and Storage of Rice

(Continued from page 160)

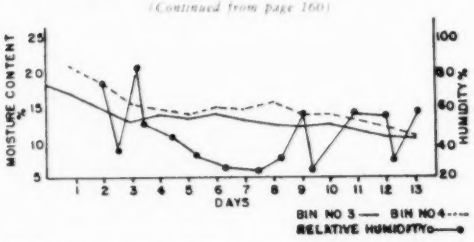

Fig. 1 Average moisture content of rice and humidity as recorded daily

Now standards for grading rough rice and machines for minimizing human errors in hulling and milling as far as possible have been developed and will be adopted as the government official standard as of July 1, 1951. These standards and machines should enable the farmer and miller each to arrive at a truer value for each lot of rice.

Drying of rice in bins by aeration with both atmospheric and heated air has been practiced with varying success for several years. Quite a few of these installations have failed and are no longer in use for rice. A good many 500 and 1000-bu galvanized iron bins have been sold in Arkansas and a few in Louisiana in the past two years for drying and storage of rice and soybeans. Drying and storage tests in 500 and 1000-bu galvanized iron bins was started in Louisiana with the 1950 crop. Two different lots of undried Zenith rice with initial moisture contents of 19.2 per cent and 22.5 per cent were successfully dried by drawing air down through the rice in the 500-bu bins.

As shown in Fig. 1 the rice was aerated for a period of 13 days and tests made to determine grade, milling quality, fatty acids, and germination. However, it should be noted that there were several days of abnormally low relative humidity and the entire 13 days were very dry with no rain or fog. The 45-yr average relative humidity for the Louisiana rice area during November is 72 per cent. The rice was removed from the bins and a second lot of Zenith rice with moisture contents of 22½ per cent was put in the bins. Relative humidities were slightly higher during the second test, but well below the average for Louisiana and no rain fell during this test. The rice was aerated for 45 days when the fans were stopped. This rice is still in storage and in good condition.

Two lots of rice of 21½ per cent moisture were placed 6 ft deep in two 1000-bu bins and dried by forcing heated air up through the rice. A portable gasoline engine driven fan was used in this test. The air was pulled over the engine and raised 8 to 10 F above the surrounding air. This test was run during the same period as shown in Fig. 1 above with abnormally low relative humidity. The unit was operated for 11 days using 0.708 gal of gasoline *(Continued on page 164)*

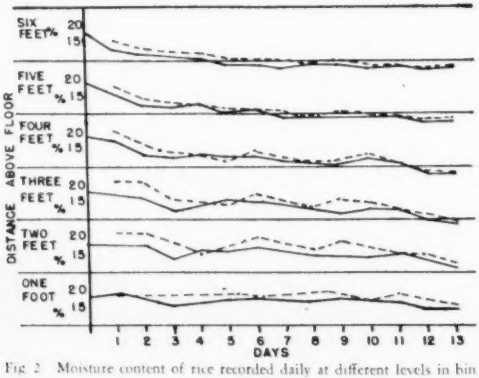

Fig. 2 Moisture content of rice recorded daily at different levels in bin

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The Importance of Expanding Aluminum Production in the Maintenance and Development of the American Farm Plant

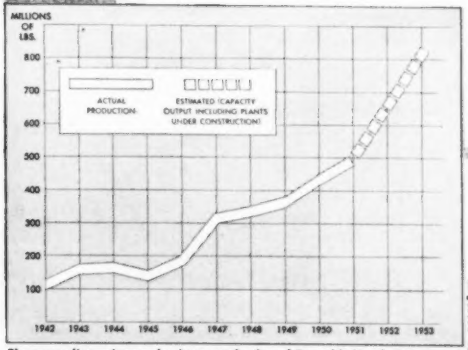
It is conservatively estimated that 3 to 4 million farm structures will need re-roofing this year. In addition, new buildings will be required for the Farm Plant necessary to supply this country and much of the world.

If aluminum roofing and siding are used for this repairing and new building, replacement will be indefinitely postponed or eliminated . . . maintenance cost will be reduced to a minimum . . . and farm productivity, particularly from livestock and poultry, will be definitely increased.

In some types of farming, the use of aluminum is now considered essential to profitable operation. For example, Texas poultry farmers depend upon aluminum's radiant heat reflection . . . to save their flocks in hot weather, to improve broiler weight gain, and to stimulate egg production.

Naturally, military requirements for aluminum must come first. But to meet these important farm needs is one of the major goals of today's production expansion. The chart below illustrates the progress achieved and in course by the Reynolds Metals Company.

REYNOLDS FARM INSTITUTE



The expanding primary aluminum production of Reynolds Metals Company — a historic chapter in the company's 33 years of continuing growth.

"The Kate Smith Evening Hour" on Television, Wednesdays—Tallulah Bankhead in "The Big Show" on Radio, Sundays—NBC NETWORKS

It's important in crop spraying to get thorough coverage of the crop. That calls for reliable equipment like the Aero Mist Master which depends on STOW flexible shafting to transmit power from the accessory gear box to the pump which delivers the insecticide to the spray nozzles beneath the wing.

According to Mabry I. Anderson, of Mississippi Valley Aircraft Service, manufacturers of the Aero Mist Spray System, "Your shafts have never failed—even though they've already given us thousands of hours of *trouble free* service".

Consider STOW flexible shafting for your next Power Drive or Remote Control application. Our engineering department will be happy to work with you. No obligation, of course.

◀ ***Write today*** for your free copy of Bulletin 515 containing complete engineering data on STOW flexible shafting.

See us in SWEET'S CATALOG

STOW MANUFACTURING CO.
39 SHEAR ST. BINGHAMTON, N. Y.

Bulk Drying and Storage of Rice

(Continued from page 162)

per barrel of rice dried. As shown by Fig. 2, it was necessary to overdry the bottom 4 ft in order to get the fifth and sixth foot dry. An electrically driven fan and thermostatically controlled fuel-oil heat exchanger arrived too late to be used on fresh combined rice and is not reported here. The one year's data from the above tests indicates the definite possibilities of developing on-the-farm drying and storage units. Expanded tests are to be made in Louisiana with the 1951 crop.

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Gile, Bueford M., and Quinn, Olin B. Cooperative Rice Marketing in Louisiana. Louisiana Rural Economist, vol. 13, no. 2, pp. 2, 5 and 6 (May, 1951).

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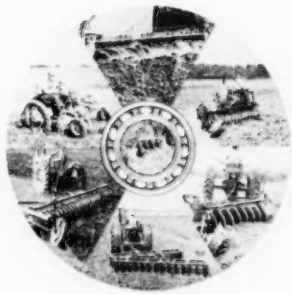
NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

New Departure Bearings Booklet. "New Departure Ball Bearings on Disc Implements" is a new 18-page booklet featuring examples of current disk-bearing mounting design. Each mounting is shown in axial cross section supplemented by a halftone of the bearing represented and brief text on the application. There are twelve of these examples, covering single and two-bearing mountings for rolling coulters; single and two-bearing rotating-shaft and rotating-housing mountings for disk



Cover of New Departure Booklet

plows, and one-way plow, disk harrow and disk-tiller mountings. The designs are indicated as well suited to the radial and thrust-load characteristics of the ball bearing and to simplified, low-cost mounting. The edition is limited, but while the supply lasts copies will be furnished on request to designers of disk-tillage equipment and to teachers of farm equipment design. Requests may be addressed to New Departure, Division General Motors Corp., Bristol, Conn.

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FarmNews

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MORE POWER TO THE AMERICAN FARMER through more electricity on the farm

RADIANT HEAT REDUCES CHICK LOSSES!

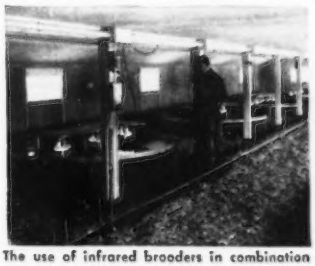
New method of brooding cuts mortality, produces faster-feathering chicks for N. Y. broiler grower

From 100 to 125 chicks per lamp can be brooded with a G-E infrared lamp brooder like this one, depending on geographical location, season, and house construction.

Dave Roach, who starts 1200 to 1500 broiler chicks each week on his farm near Albany, N. Y., is one of many enthusiastic boosters of radiant heat brooding. He uses G-E infrared lamps over the floor and G-E heating cable under it, and finds this type of heat keeps litter dry, thus controlling disease germs and reducing mortality. "Moreover," says Mr. Roach, "my chicks feather faster, and have keen appetites that produce faster growth."

Use Either or Both

When used alone, either thermostatically controlled infrared lamps, or heating cable (in some circumstances) will give satisfactory brooding temperatures and excellent results. In northern states, however, a combination of both is recommended. Radiant heat is practical for brooding in lots of 50 to 50,000 chicks, but regardless of the size of installation G-E lamps, heating cable and thermostats assure economical dependable service with a minimum expenditure of time and labor. For more information, check "Radiant Heat Brooders" on the coupon.



The use of infrared brooders in combination with automatic feeders and waterers makes it possible for one man to take care of at least 40,000 chicks of the same age.

BARN CLEANER SAVES 2 MAN-HOURS PER DAY!

"Barn cleaning used to be a 1½-hour job for two men," says Mr. Kooistra, who has a 400 acre dairy farm near Alden, Ill. "Now," he continued, "with the help of my electric barn cleaner, two men can do the same job in 20 minutes. That amounts to a saving of over 2 man-hours a day."

Considered Essential

Savings in time and labor like those reported by Mr. Kooistra show why electric barn cleaners are considered by many dairymen to be essential pieces of equipment on the farm. The time saved not only permits farmers to take better care of their herds, but enables them to keep more cows or devote the time to better sanitation practices.

For Any Shape Barn

Barn cleaners run quietly and can be installed in barns of any shape. Like many other models on the market today, Mr. Kooistra's barn cleaner is equipped with 3-hp General Electric motor and G-E starter for "on-the-job" dependability and long life with minimum maintenance. For more details, check "Barn Cleaner" on the coupon.

NO RAIN IN SIGHT? THEY MAKE THEIR OWN!

An electric pump makes it possible to save crops from damage during dry spells. Whether for truck crops, pasture, or just home gardens, supplemental irrigation pays off.

Even in areas of high annual rainfall, farmers agree that providing "man-made" rain pays big dividends. Whether it's just a rubber hose for the farm garden or a new electric pump for field irrigation, the investment will quickly pay for itself in increased crop yield and quality. They agree, too, that for reliable, low-cost service you can't beat electrically driven pumps.

Stand Up Under Hard Use

These pumps, available in many different capacities and pressures, are ruggedly built to stand up under hard use. Jack Harris, for instance, has a 2-hp G-E motor-driven pump on his 830 acre ranch near Conroe, Texas, that has given months of reliable service with little attention other than routine maintenance. When a farmer buys a pump he wants a drive he can trust. That's why so many farmers prefer G-E pump drives. For more data, check "Irrigation Pump" on the coupon.

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Section 671-20E, Schenectady 5, N. Y.

I would like additional information on the following equipment:

☐ Radiant Heat Brooders ☐ Barn Cleaner
☐ Irrigation Pump

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Suggestions for Improving ASAE Meetings

To the Editor

THIS letter is addressed in particular to ASAE members (a) who are in responsible charge of arranging programs for both section and national meetings of the Society and (b) who accept assignments as speakers on these programs.

On returning from the ASAE winter meeting at Chicago last December, five members of the agricultural engineering staff of Virginia Polytechnic Institute, who attended the meeting, gave a report of the meeting to the entire staff. This report covered the high lights of the meeting, and included reports on interesting new information gained and comments on the quality of presentation of papers, good and bad. The latter brought out considerable discussion from all staff members, and while it centered around the meeting in Chicago, it applied as well to other national and section meetings of ASAE. The following ideas and suggestions are therefore for consideration of all who have anything to do with out meetings and are offered for what they may be worth to all who have anything to do with arranging and contributing to them.

1. In much of the work of agricultural engineers close cooperation with other specialists—physiologists, biologists, soil physicists, chemists, electrical engineers, etc.—is required. Whenever one of these specialists, carefully selected not only for his technical knowledge but also for his ability to present it, has addressed a Society meeting, he has been well received. We believe the Society should continue to encourage this sort of thing in connection with its meeting programs.

2. There has been a tendency in recent years for many of our Society meeting papers to be presented by other than the men who actually conducted the work being reported. Such presentations have lacked the punch that would have been given them if presented by the men who conducted the work. However, in the case of broad fields of work or summaries of work over extended periods of time are presented, then heads of departments or others might well be called upon to make the presentation.

3. We believe more good will come out of a program through prearranged discussion material planned jointly by the speakers and the presiding chairmen. One or more "planted" questions will often break the ice and get discussion started.

4. Another shortcoming of many of our ASAE meetings is the rather ineffective presentation of material. Following are some of the varying examples of this, along with suggestions for improvement:

(a) There is a tendency to attempt to include too much data and irrelevant detail which submerges the important objectives of a paper. We believe that papers before our Society meetings should cover only basic causes, methods, and results, the detail being left for study and review when the paper is published.

(b) The effectiveness of many papers is lost by being read. The Southeast Section, for example, on several occasions has specifically requested speakers on its programs not to read their papers. The result has usually been most successful.

(c) Much of the visual aid material has been rather inferior. Too much material on a slide, line weights too light for projection distance, slide proportions that fail to make full use of screen area, etc. Most of the poor results obtained is probably due to not knowing how to prepare slide copy. Excellent instructions are available in two publications as follows: "Guide for the Preparation of Slides and the Use of Projection Equipment," H. E. Meyers, Journal of Agronomy Society of America, 40:1141-1142, and Soil Science Society of America, Proc. 13:576-577, and "Preparation of Effective Lantern Slides," L. S. Bonnell, 1949, Chem and Eng. News 27: No. 37, 2600-2606. A third reference is "The Preparation and Use of Visual Aids" by Kenneth B. Haas and Harry A. Packer, Prentice-Hall, Inc., New York, N. Y., 1948. We have found these references most helpful in preparing effective slide material and believe it would be worth while for agricultural engineers to provide themselves with similar helpful material in the preparation of meeting papers.

(d) The public address systems now in use do not permit speakers freedom of movement without losing contact with their audience. We would therefore suggest that a high-quality lapel microphone be made available for our meeting programs. The somewhat transient attendance in some of our ASAE meeting sessions make a good audio-presentation an absolute necessity.

The foregoing comments are not to be taken as criticisms, but rather as constructive suggestions to assist in the continued improvement of ASAE meeting programs. We also think it would be helpful if a small, carefully selected committee were picked to work with recognized leaders in the field of speech and visual aid work in order to develop suitable material that could be made available to speakers and which would assist them in preparing and presenting more effective papers.

T. W. Edminster
V. H. Baker
J. P. Walker
J. M. Stanley
L. F. Charity
Agricultural engineering staff members
Virginia Polytechnic Institute, Blacksburg

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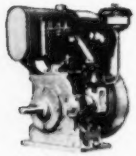
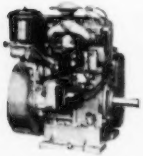
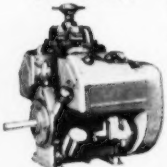


6 to 9 hp. models.



7 to 13 hp. models.



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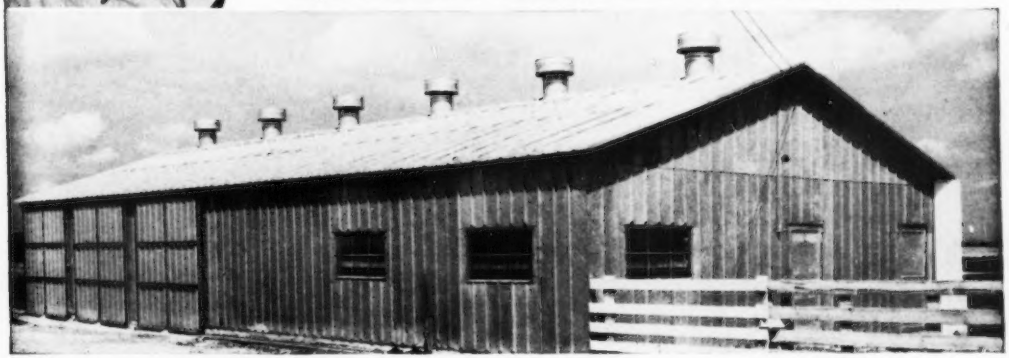
says CHARLES H. BOROP, R.R. No. 4, Princeton, Illinois



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"The heavy steel frame does away with the need for trusses or posts. It makes this building handy for storing hay as well as farm equipment when the hay is removed.

"The livestock are comfortable in winter and summer. The heavy galvanized steel covering gives us maximum fire-safety, low upkeep, neat appearance and long life. We expect these things to pay dividends for many years."

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UNITED STATES STEEL

Applicants for Membership

The persons listed below have applied for admission to membership or for transfer of membership grade in the American Society of Agricultural Engineers. Members of the Society who wish to commend or object to any of these applicants should write the Secretary of the Society at once. If there are no objections, and if confidential statements furnished by their references are satisfactory, these applicants will be voted on by the Council after April 15, 1952.

BREMBECK, H. S.—Mgr., farm animal equip. div., United Cooperatives, Inc., Alliance, Ohio.

BUSHELEY, RICHARD W.—Project engr., J. I. Case Co., Rockford, Ill.

CHARITY, LINUS I.—Inst. in agr. eng., Virginia Polytechnic Inst., Blacksburg, Va.

CHEATHAM, DANIEL W., JR.—Student, Virginia Polytechnic Inst., Blacksburg, Va.

CHECKLEY, PETER I.—Chief des. engr., Steel Fabricators, Ltd., Cardiff, England.

CUNNINGHAM, ERNEST R., JR.—Tooling engr., Butler Mfg. Co., Kansas City, Mo.

DALE, RALPH G.—Dist. sales engr., Chain Belt Co., Chicago, Ill.

DENNISTS, H. HOYT—Asst. project engr., Deere & Co., Moline, Ill.

DORAN, JOE V.—Fieldman, dept. 7555, Sears Roebuck & Co., Atlanta, Ga.

EGGLESTON, JAMES C.—Student, Virginia Polytechnic Inst., Blacksburg, Va.

FIRK, JOHN C.—Dist. sales agr., Chicago Rawhide Mfg. Co., Chicago, Ill.

FOURKIS, EUGENE A.—Res. student, King's College Union, Newcastle-on-Tyne, England.

FUTRAL, JOHN G.—Agr. engr., Georgia Exp. Sta., Experiment, Ga.

GARNER, J. K.—Farm mach. specialist, Ministry of Food and Agr., Karachi, Pakistan.

GIERTZ, ROBERT W.—Jr. engr., John Deere Waterloo Tractor Wks., Waterloo, Iowa.

JONES, THOMAS R.—Mgr., barn cleaner div., Starline, Inc., Harvard, Ill.

KARM, LESTER V.—Draftsman, res. dept., Dearborn Motors Corp., Birmingham, Mich.

KRENZ, ALFRED S.—Pres. and sales engr., Krenz & Co., Inc., Milwaukee, Wis.

LAKIN, OSCAR—Vice-president, A. Lakin & Sons, Inc., Chicago, Ill.

LEONARD, ARTHUR S.—Specialist, agr. eng. div., University of California, Davis, Calif.

MCPHAIL, THOMAS E.—Mgr., tractor dept., General Utility Co., Inc., Dunn, N. C.

MOHL, HAROLD H.—Engr., exp. dept., John Deere Harvester Co., East Moline, Ill.

MOHSENIN, N.—Graduate student, University of California, Berkeley, Calif.

MUCIBABICH, PETER R.—Designer, McCormicks Wks., International Harvester Co., Chicago, Ill.

O'DWYER, PATRICK S.—Agr. editor, Free Press Weekly Prairie Farmer, Winnipeg, Man., Canada.

PANKOWSKI, W.—Stress analyser, J. I. Case Co., Bettendorf, Iowa.

PHELGAR, ARCHIE G.—Student, Virginia Polytechnic Inst., Blacksburg, Va.

SCHOLL, O. F.—Mgr., Hay machine sales, International Harvester Co., Chicago, Ill.

SMITH, DONALD G.—Engr., Hester Flow Co., Inc., Jacksonville, Fla.

SPATES, CHARLES D.—The London Machinery Co., Fairfield, Iowa.

SPILMAN, ROY M.—Chief engr., Durkee-Atwood Co., Minneapolis, Minn.

ULEMAN, TURRELL—Tech. rep., Pittsburgh Plate Glass Co., Pittsburgh, Pa.

VAN JAHNKE, WILLIAM—Mgr., farm elec. sales div., Farm Journal, New York, N. Y.

VINCENT, JOHN R.—Agr. engr., divs. of agr. eng., Agr. Res. Center, Beltsville, Md.

WHITE, REGINALD S.—Design engr., Hilbe Eng. Inc., Glendora, Calif.

TRANSFER OF MEMBERSHIP

DENNISTON, WILLIAM I.—Design engr., eng. dept., John Deere Harvester Wks., East Moline, Ill. (Associate Member to Member)

DREW, L. O.—Assoc. prof. of agr. eng., University of Georgia, Athens, Ga. (Associate Member to Member)

MILLER, D. O. H.—Sales engr., French & Hecht, Davenport, Iowa. (Associate Member to Member)

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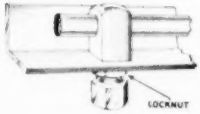

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DES MOINES IOWA

NEW BOOKS

THE GEOGRAPHY OF HUNGER, by Josue de Castro. Cloth, xii + 337 pages, 5¾ x 8½ inches. Indexed. Little, Brown and Co. (34 Beacon St., Boston 6, Mass.) $4.50.

The author writes from a background of scientific training, service in the Institute of Nutrition, University of Brazil, and experience as chairman of the Executive Council, Food and Agriculture Organization of the United Nations. He develops two related and not generally popular propositions: (1) that mass hunger affecting two-thirds of the world's population is a man-made plague rather than a natural phenomenon, and (2) that this hunger is a cause rather than a result of overpopulation. He is optimistic about prospects for progress as a long-range possibility, and recognizes a need for higher standards of productive efficiency as one important factor in its realization. Chapters cover: The taboo of hunger, the gamut of hunger, hunger in the new world, hunger in ancient Asia, hunger in the dark continent, starving Europe, the advance against hunger, and geography of abundance.

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NEW BULLETINS

Half a Century of Electric Progress on the Farm. Philadelphia Electric Co., (Philadelphia, Pa.). A pictorial of increasing farm use, accompanied by a minimum of text.

Adequate Farm Wiring Demonstrations. Iowa Rural Electric Cooperative Assn. (Des Moines). A guide to individual electrification advisers on setting up demonstrations to show farm people the results of good and poor wiring, with particular reference to simple two-wire circuits, polarization, meters, wiring for safety, 115-230-v hook up, three-wire practice, voltage loss in wire, cost of electricity lost in wires, wire sizes required, performance comparison, load center distribution, motor overload protection, electric motors, motor hookup and cleaning electric motors. A list of materials and equipment needed to assemble a demonstration kit is included.

A Graphic Method of Calculating Spray Mixes. by James E. Garton and M. J. Morgan. Oklahoma Agricultural Experiment Station (Stillwater) Miscellaneous Publication MP-25, (July, 1951). This folder is an aid to computation of relationships between percentage strength by weight of liquid concentrate, pounds of active ingredient per gallon of concentrate, specific gravity of liquid concentrate and weight in pounds of one gallon of concentrate, and pounds active ingredient per acre, gallons of spray material per acre, gallons of spray material to be mixed, pounds of active ingredient per gallon of concentrate (or percentage strength of wettable powder) and gallons of concentrate required (or pounds of wettable powder required).

Manufacturers Specifications for Household Electric Clothes Driers. Rural Electrification Administration, U.S. Department of Agriculture (Washington, D.C.). Tabulated data on primary features of 21 makes of driers.

Farm Trailers, Wagons, and Racks, by W. Kalbfleisch, J. M. Armstrong, D. J. Cooper, and A. I. Magee. Publication 830, Canadian Department of Agriculture (Ottawa). Revision (July, 1951) brings up to date information on the subject previously published in several separate circulars.

Abstracts on Lighting and Wiring. Unnumbered publication of the Rural Electrification Administration, U.S. Department of Agriculture (Washington, D.C.). Shows related associations, books, government agencies, laboratories, magazines, manufacturers, state colleges, and the USDA and technical societies.

Irrigation Research in the Tennessee Valley, by W. H. Dickerson, Jr. Special Report No. 36 (January, 1951), agricultural engineering and processing branch, division of agricultural relations, Tennessee Valley Authority (Knoxville). A progress report showing generally increased yields and net returns with sprinkler irrigation in the TVA area.

The Mulch Drill, by W. M. Anderson and R. C. Hines, Jr. Special Report No. 37 (March, 1951), agricultural engineering and processing branch, division of agricultural relations, Tennessee Valley Authority (Knoxville). Reports on development and testing of a drill for use in stubble mulch culture for soil conservation.

Farm Electrical Customers — Their Buying Habits and Attitudes Toward Retailers. Farm Electrification Bureau, National Electrical Manufacturers Assn. (155 E. 44th St., New York 17, N. Y.) and *Country Gentleman* (Independence Square, Philadelphia, Pa.). Reports on results of a survey on the subject, with sections on major electrical household appliances, electrical farm production equipment, electrical lighting and wiring equipment, and general questions.

Remodeling Barns for Better Dairy Stables, by A. M. Goodman. Cornell (Ithaca, N. Y.) Extension Bulletin 742 (November, 1951). Features of the dairy stable are reviewed in relation to modern dairy practices and knowledge of requirements, and remodeling is presented in terms of major changes and the handling of specific structural details.

What About Special Tires for Winter Driving. 1951 Report of the Committee on Winter Driving Hazards, National Safety Council (Chicago, Ill.). Reports extensive tests on tires with special treads, showing improvement over conventional tires for specific conditions. The most significant conclusion drawn by the Committee is that the overall performance of these tires thus far justifies no reduction in safety precautions for driving on slippery surfaces.

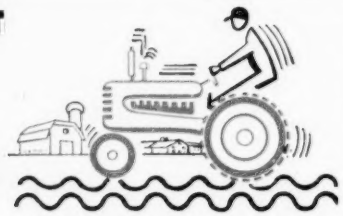
Progress Report of the Washington Farm Electrification Committee, 1951, by J. Roberts (Pullman). This 27th annual report covers progress during the year on poultry brooding studies, heat lamp studies, preliminary study of the fire hazard of a heat lamp, pig brooders, and a plywood self-feeding silo.

Removal of Air from Dairy Stables, by Wm. Kalbfleisch and J. W. White. Reprint from *Scientific Agriculture* 31:492-495, November, 1951. (Central Experimental Farm, Ottawa, Can.). Discussion of the relative advantages of floor and ceiling outlets, with the balance indicated to favor the ceiling location.

Adequate Interior Wiring, by Wm. H. Knight. Idaho (Moscow) Farm Electrification Leaflet No. 16 (December, 1951). Four pages of guidance to farmers on their wiring problems.

EVEN THE MOST

Violent Vibration



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RUGGED

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Specially designed for heavy-duty service, Rochester Tractor Gauges are built with vibration and pulsation dampeners.

There's no danger of accuracy loss through rough riding. Even high overloads can't damage their sensitive movements, or cause their pointers to flutter. They *keep on* delivering accurate readings, too, year after year, because of their unusually rugged construction.

And for *extra* protection, Rochester gauges are *permanently* sealed behind heavy glass crystals. Dirt and water just can't get in. This outstanding dependability has made Rochester Gauges the choice of all leading tractor manufacturers for more than 35 years.

Rochester Manufacturing Company, Inc.
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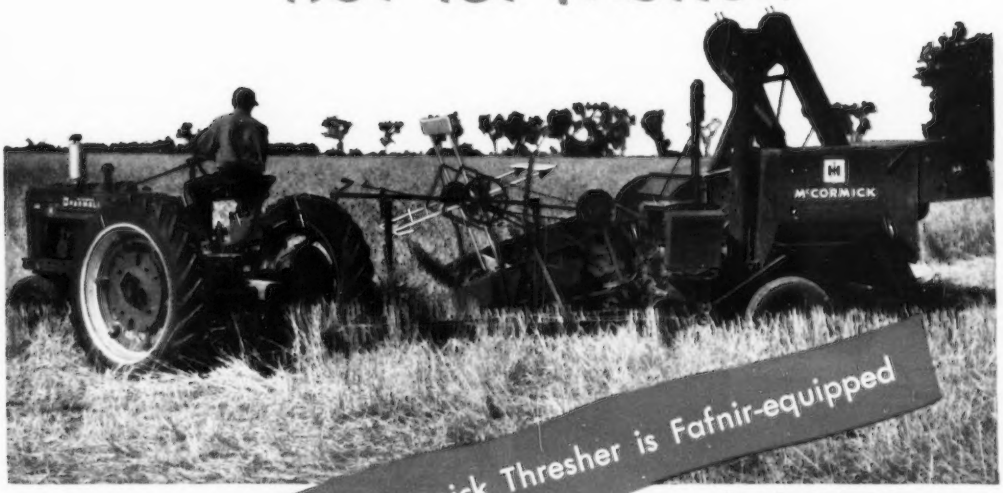
DIAL THERMOMETERS GAUGES AMMETERS

Power for threshing... not for friction



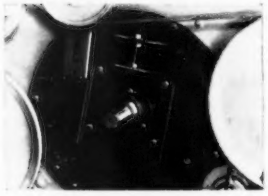
because this McCormick Thresher is Fafnir-equipped

This McCormick No. 64 Harvester-Thresher with a 6 ft. cutter bar features straight through, balanced flow movement.

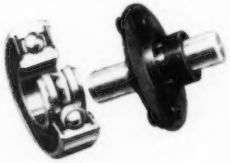
Power gets right down to business the moment it's applied on the McCormick No. 64 Harvest-Thresher. No fighting friction at the start or at any time, because the Thresher's high speed shafts are installed on Fafnir Ball Bearings with lubricant sealed in. The results . . . low cost operation from every angle.

"The 64 Thresher continues to rotate several minutes after the power is shut off," says one enthusiastic owner. That's a tribute to its balanced designing and its ball bearings, too . . . a reason why the machine is so easy to haul.

Like other leading manufacturers of farm equipment, International Harvester has made good use of Fafnir Bearings over the years. Twelve of them are used on the McCormick No. 64 Harvester-Thresher. Ten are Flangettes with the famous Fafnir Wide Inner Ring Bearings and self-locking collars. There's more than just good bearings involved however . . . the Fafnir attitude and aptitude . . . a way of looking at ball bearings from the designers' viewpoint and an aptitude gained from over 40 years' specialization in ball bearings. The Fafnir Bearing Company, New Britain, Conn.



This close-up illustration shows Fafnir Ball Bearing Flangette and spacing adjustment between cylinder and concave.



Fafnir Flangette ball bearings with Mechani-Seals are used on cylinder, cylinder beater, feed beater, shaker shaft and fan shaft. Mechani-Seals positively exclude dust and dirt — prevent grease leakage. Fafnir radials with Plya-Seals are used on other turning points. Plya-Seals retain lubricant for life.

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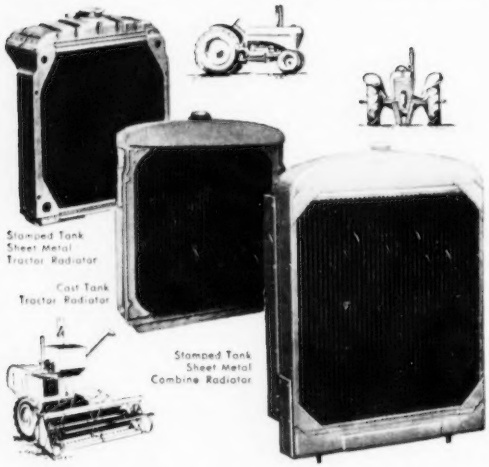
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

Farm equipment manufacturers:

ARE YOU GETTING THE MOST FOR YOUR RADIATOR DOLLAR?



See the newest Young design features before you decide

There *is* something new in tractor and implement radiators! Let us show you how Young engineering, modern production machines, and careful attention to details in manufacturing combine to produce radiators that are simpler in design, less costly to make, and more efficient in performance. This, we believe, explains the fact that more and more manufacturers of farm and industrial tractors and self-propelled farm implements are turning to Young for their heat transfer requirements.

Be sure *you* are getting the best possible radiator value. Send us your requirements, let us show you our product, then compare our proposal. Incidentally, we can offer similar economies, including *complete* "packaged cooling," in passenger car, truck, bus, aircraft and stationary engine applications.

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25 YEARS OF PROGRESS IN HEAT TRANSFER ENGINEERING

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Heat Transfer Products for Automotive and Industrial Applications.

Heating, Cooling, Air Conditioning Products for Home and Industry.

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NEWS SECTION

ASAE Meetings Calendar

March 14 and April 11—WASHINGTON (D.C.) SECTION, Room 6062, South Bldg., USDA, Washington.

March 21—OHIO SECTION, Ives Hall, Ohio State University, Columbus.

April 4 and 5—VIRGINIA SECTION, Natural Bridge Hotel, Natural Bridge, Va.

April 10 and 11—PENNSYLVANIA SECTION, Agricultural Engineering Bldg., Pennsylvania State College, State College.

April 11 and 12—SOUTHWEST SECTION, Grim Hotel, Texarkana, Tex.

MAY 9—MINNESOTA SECTION, University of Minnesota, University Farm, St. Paul.

May 16 and 17—ALABAMA SECTION, Gulf Breeze Inn, Gulf Shores, Ala.

June 16-18—45TH ANNUAL MEETING, Hotel Muehlebach, Kansas City, Mo.

August 25-27—NORTH ATLANTIC SECTION, University of Maine campus, Orono.

December 15-17—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan.

Southeast Section Elects Dunkelberg As New Chairman

GEORGE H. DUNKELBERG, associate agricultural engineer, South Carolina Agricultural Experiment Station, Clemson, was elected the new chairman of the Southeast Section of the American Society of Agricultural Engineers at its meeting February 4 to 6 held at Atlanta, Ga., in conjunction with the annual convention of the Association of Southern Agricultural Workers. He succeeds Fred A. Kummer of the Alabama Polytechnic Institute. At this meeting the Section also elected two vice-chairmen for the ensuing year. G. W. Giles, head, agricultural engineering department, North Carolina State College, Raleigh, and H. D. White, agricultural engineer, University of Georgia, Athens. G. D. Kite, associate extension agricultural engineer, Virginia Polytechnic Institute, Blacksburg, was elected secretary.

At its meeting the Section chalked up a new record for attendance, the total registration being 177, a large percentage of whom were ASAE members.

The Southeast Section meeting in 1953 will be held the first or second week in February, at New Orleans.

Tavernetti New Chairman ASAE Pacific Coast Section

JAMES R. TAVERNETTI, agricultural engineer in the agricultural experiment station, University of California, Davis, was elected chairman of the Pacific Coast Section of the American Society of Agricultural Engineers at the yearly meeting of the Section held this year on the University of California campus at Davis on January 31.

Franklin H. Watson, Jr., senior agricultural engineer, East Bay Municipal Utility Dist., Lodi, Calif., was elected the new vice-chairman of the Section, and Walter W. Weir, drainage engineer, division of soils, University of California, Berkeley, was re-elected secretary-treasurer. Alfred S. Gray, resident engineer, Rain Bird Sprinkler Mfg. Co., at Azusa, Calif., was elected a member of the Section executive committee.

The new Nominating Committee of the Section is comprised of Fred A. Brooks (chairman), Robert M. Magee, and Ronald C. Reeves.

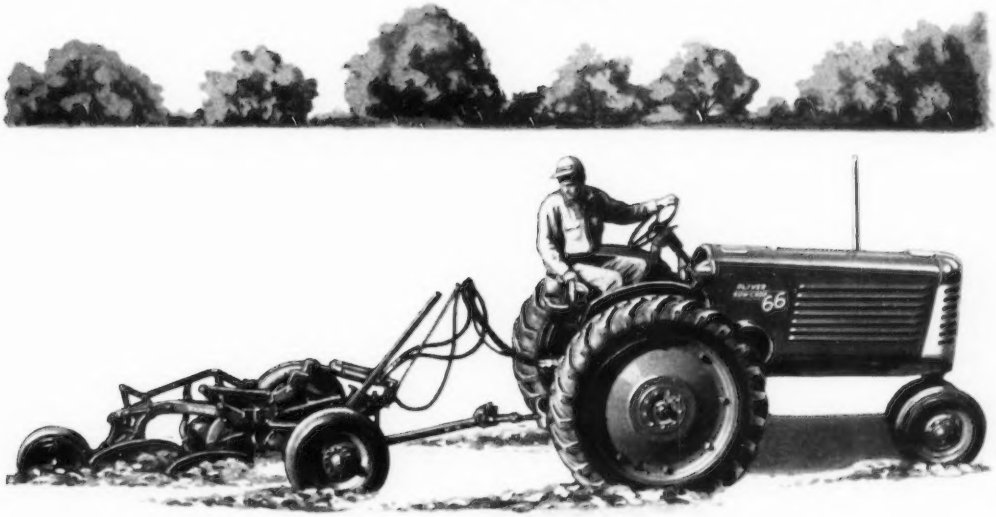
The program of the meeting, reported in an earlier issue of AGRICULTURAL ENGINEERING, was of unusual interest and attracted a large attendance.

During the past year, the executive committee of the Section has been studying the recommendation made at the meeting a year ago, to invite the parent Society to hold its annual meeting in California in 1954 or 1955, and following the committee's report at this year's meeting, the Section at its business session voted to extend the Society an invitation to hold the 1955 ASAE annual meeting in California. The exact site of the meeting is to be determined later.

(News continued on page 174)

It's Here

the New OLIVER 2-PLOW "66" *Diesel!*



Now, Oliver brings you the advantages of a diesel tractor in the 2-plow power class! And, like its bigger brothers, the "77" and "88", it has a combination of advancements found in no other tractor of comparable size!

This full 2-plow, diesel-powered "66" is equipped with a husky 4-cylinder, overhead valve engine with an oil-saving lubrication system . . . removable, wet cylinder sleeves . . . by-pass cooling system for quick, uniform warm-ups . . . precision-type bearings and many other efficiency and long-life features.

That isn't all! You get six forward speeds in the Oliver "66", plus the amazingly comfortable rubber spring seat, Oil Miser transmission case, and grouped controls that make it as easy to handle as a car. Available, too, are time-saving Direct Drive Power Take-Off that often eliminates the need for an auxiliary engine on PTO-driven machines, and the fast, smooth "Hydra-lectric" hydraulic lift that gives you *complete* implement control.

See and drive the new Oliver "66" diesel! Note how easily it starts, how smoothly it runs. It was *designed specifically for the farm*, and your Oliver dealer will gladly explain how it operates, then calculate for you the surprising savings in operating upkeep. Start farming with an Oliver "66" diesel and you'll make a good start in reducing farming costs! The OLIVER Corporation, 400 West Madison Street Chicago 6, Illinois.

OLIVER

"FINEST IN FARM MACHINERY"

McKibben to Head USDA Engineering Research

THE U. S. Department of Agriculture has announced the appointment of Dr. E. G. McKibben as the new director of agricultural engineering research in the Bureau of Plant Industry, Soils, and Agricultural Engineering at Beltsville, Md. He was named to the position by Dr. A. H. Moseman, chief of the Bureau.

A leader in his profession for many years and an international authority on tillage mechanics, Dr. McKibben has recently been in charge of the Department's Tillage Machinery Laboratory at Auburn, Ala. He is a graduate of Iowa State College in agricultural engineering, did advanced work at the University of California, and later returned to Iowa State as associate professor of agricultural engineering for 14 years during which he earned his Ph.D. degree. In his graduate studies, Dr. McKibben gave special attention to soil mechanics and soil physics. After completing work on his doctor's degree, Dr. McKibben was head of the department of agricultural engineering at Michigan State College for a number of years. Later he was in charge of agricultural engineering work for the Pineapple Research Institute at Honolulu before entering the Department.

In his new position Dr. McKibben becomes leader of the Department's national agricultural engineering research program carried on cooperatively with the state agricultural experiment stations and closely coordinated with the research of private industry and other federal agencies. It deals with machines, materials, methods, power and labor, farm buildings and housing, and the application of electricity in processing and other farming operations. This work is carried on in four research divisions, which are the Divisions of Farm Machinery, Farm Buildings and Rural Housing, Mechanical Processing of Farm Products, and Farm Electrification.

Dr. McKibben spent his early childhood on a rice farm near Almyra, Ark., but later his family moved to Marshalltown, Iowa, where he attended high school. During his professional engineering career he has made numerous contributions to research literature. In 1949 he received the Cyrus Hall McCormick gold medal awarded annually by the American Society of Agricultural Engineering for exceptional and meritorious engineering achievement in agriculture. He also is co-author of two textbooks on farm machines and power.

The appointment of Dr. McKibben as director of agricultural engineering research fills a vacancy left by the passing last fall of Arthur W. Turner.

Michigan Section Has Good Program

MORE than 150 ASAE members and guests attended the meeting of the Michigan Section of the American Society of Agricultural Engineers, February 16, at the offices of the Dearborn Motors Corp. in Birmingham, near Detroit.

Jack R. Schram, vice-chairman of the Section, presided and opened the meeting by introducing R. E. Hunt, vice-president in charge of engineering and manufacturing, Dearborn Motors Corp., who welcomed the group on behalf of the Company.

J. C. Cahill, farm service coordinator, Detroit Edison Co., and the first speaker, talked on rural electrification and national defense, emphasizing the part electric power now plays in farm production and labor saving.

Norman Billings of the Michigan Division of Water Resources discussed water resources in Michigan, including some typical pollution problems and the current high-water phase of the Great Lakes water-level cycle. Because of its position and geological formation, he said, Michigan has its own surface and groundwater problems not closely related to the specific similar problems of adjoining states.

Farm structures interest in the program was represented by a contribution on solar heating for farm buildings by W. Everett Eakin, director of farm research, Libbey-Owens-Ford Glass Co. He reviewed briefly the principle of heat transmission through sealed double panes, and reported on some current research in farm applications of solar heating.

The Dearborn Motors organization furnished lunch in the company cafeteria in the building. This was followed by a short conducted tour of the engineering laboratories.

A report on combine feeding studies by W. H. Johnson, Ohio Agricultural Experiment Station, noted variations in the angle of approach of grain heads to the combine cylinder in various designs, and suggested that the problem of "sick wheat" may be related to variations now grown for combining rather than to moisture conditions associated with combining.

Frank Irons, senior agricultural engineer, USDA, reported on new developments in spraying and dusting. He indicated that improved adhesion is being obtained with concentrate or low-gallonage spraying, and that this is helping to improve pest control results where the material, equipment, and application method provide adequate uniform coverage. He showed moving pictures of airplane spraying and dusting operations in Texas, including some shots of the plane specially developed there for agricultural use.

(Continued on page 176)

Milsco
MILWAUKEE
Commander
HEAVY DUTY CUSHION SEAT
WITH FORE AND AFT ADJUSTMENT
Popular for most types of mobile equipment. Quickly adjustable forward or backward with a flick of the adjusting lock-handle. Full-comfort roomy cushion seat and restful padded back. "No-Sag" synchronized action springs. Foam rubber or sisal and cotton. Artificial or genuine black cowhide.
many other styles
MILSCO JUNIOR
NO. 811
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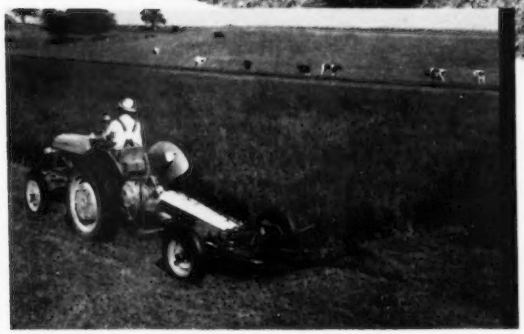
FORE AND AFT ADJUSTMENT LEVER
Simple Adjustment Fore and Aft
MILSCO MANUFACTURING COMPANY
2732 N. 33rd STREET
Famous in Seating
MILWAUKEE 45, WIS.

It Pays to make hay with NEW IDEAS



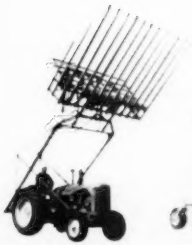
THERE IS A NEW IDEA TOOL FOR MOST EVERY HAYING NEED

Mowers, Rakes, Elevators, Stackers, Grapple Forks, Wagons—are built to give outstanding performance under most severe conditions. With New Idea haying tools, the farmer can cut all of his hay even in closest quarters, he can make light, "fluffy" windrows (or gently ted), load, haul, and store even the biggest crops in less time and with less effort.

For more complete information visit a New Idea Dealer—or write us direct.

2 Great Mowers that easily and quickly hitch to most tractors

No. 30-A trailer-type mower, with either mechanical or hydraulic lift.
No. 40 semi-mounted mower, with either mechanical or hydraulic lift.



NEW IDEA—HORN PUSH-OFF STACKER

NO. 40 SEMI-MOUNTED MOWER

NO. 30-A TRAILER-TYPE MOWER

NO. 45-G LOW WHEEL RAKE AND TEDDER

NO. 4 HIGH WHEEL RAKE AND TEDDER

NO. 175 WIDE TROUGH ELEVATOR

ALL PURPOSE FARM WAGON

New Idea dealers will consider it a privilege to have you drop in. They will be glad to furnish you with literature.

NEW IDEA
FARM EQUIPMENT COMPANY
SUBSIDIARY AVCO MANUFACTURING CORPORATION
COLDWATER, OHIO

GALVANIZED SHEETS

For PROTECTION Only galvanized sheets give you the strength of steel . . . the rust protection of zinc. Both are important in providing a strong, sound, leak-proof roof that double-guards valuable crops, livestock and machinery against damage and destruction for years and years. It's the first choice of farmers.

For STAYABILITY Galvanized roofing holds at the nail holes . . . stays leak-proof and solid year after year with a minimum of maintenance. Farmers say it cuts down overhead by saving "overhead"—often for the life of the building.

For ECONOMY Consider the economy of any roofing material with these three long-time cost factors in mind: (1) original price; (2) repair and upkeep; (3) years of serviceable life. Galvanized sheets are first choice of farmers because they know that the roof that gives them the longest, trouble-free service is the cheapest in the long run.

DON'T FORGET

Proper care pays! Material shortages are limiting new construction and replacement. Careful maintenance of present structures is more essential now than ever before. Expanding production of zinc and steel means ample supplies of galvanized sheets with the return of more normal conditions. In the meantime, a few simple steps with very little labor can extend the useful life of your galvanized roofing. The valuable booklets described below will tell you how.

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2 OZ. COATING
REG. U.S. PAT. OFF.
SEAL OF QUALITY

SEND FOR VALUABLE BOOKLETS

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Without cost or obligation, send the illustrated booklets I have checked.

- ☐ Facts About Galvanized Sheets
- ☐ List of Metallic Zinc Paint Mfrs.
- ☐ Directions for applying Galvanized Sheets
- ☐ Repair Manual on Galvanized Roofing and Siding
- ☐ Use Metallic Zinc Paint to Protect Metal Surfaces

NAME_____

ADDRESS_____

TOWN AND STATE_____

NEWS SECTION (Continued from page 174)

In reporting on new developments in farm tires, F. W. Shields, United States Rubber Co., emphasized the importance of matching tire sizes and treads to the average soil and service conditions to be encountered in their use. He indicated that wheel weights favored matching weight carried to traction requirements, but that under present conditions manufacturers could not get enough steel to provide wheel weights.

Christ Nyberg, chairman of the Section, announced proposed plans for a joint meeting with the new Ohio Section, at Toledo, May 3.

A. W. Farrall, head, agricultural engineering department at Michigan State College, urged members of the Section to attend the Farm Equipment Industry Research Conference to be held at East Lansing, May 12, 13, and 14.

D. A. Milligan, domestic sales manager, Harry Ferguson, Inc., reported for consideration the matter of a Section-sponsored agricultural engineering scholarship. He pointed out that funds to cover the cost of the scholarship for a few years were available in a surplus in the fund contributed by industry for entertaining ASAE members during the Society's annual meeting in Michigan in 1949, but that the Section might well consider the possibilities of providing for the scholarship on a permanent basis.

E. H. Kidder reported that the school of engineering at Michigan State College is interested in having various groups of engineers in Michigan hold spring meetings at the College in connection with its "Engineer's Day" student celebration. He said that most of the engineering groups already had their spring meetings for this year planned when they received the invitation, but that a number of them would probably accept the invitation another year.

PERSONALS OF ASAE MEMBERS

Albert E. Keegan recently resigned as designer for Shirley, Simons and Sons, architects, at Tyler, Tex., to become associated with the Chance Vought Aircraft Corp., Dallas, Tex. He is assigned to the technical publications department, as a technical writer on aircraft publications including handbooks and manuals for Navy contracts.

Percy F. Kiffe, who has been assistant manager of tillage and seeding machines sales of the International Harvester Co. at the Chicago office, has been transferred to the Company's district sales office at St. Paul, Minn., where he is northwest regional products specialist on tillage and seeding machines.

Robert E. Skinner recently accepted a position as irrigation sales engineer in the irrigation division of Russell Daniel, Inc., Athens, Ga. He was formerly research engineer in farm structures at the University of Kentucky.

Archie A. Stone, currently on leave as special representative of the executive offices of International Harvester Co., has been designated chief of the Machinery Price Branch, Industrial Materials and Manufactured Goods Division, Office of Price Stabilization in Washington. Mr. Stone joined OPS in February, 1951, as chief of the farm machinery and equipment section of the machinery branch, the same position he held under the OPA during World War II.

John H. Zich was recently made manager of the tractor and implement sales department of Dearborn Motors Corp., a promotion from the position of manager of new product investigation. Prior to joining Dearborn Motors in 1947, he served as a project engineer for Allis-Chalmers Mfg. Co., and as a director of agricultural testing in Army Ordnance, and was serving as assistant service manager for Harry Ferguson, Inc., at the time he joined the Dearborn Motors organization.

M. W. Loupo is now assistant agricultural engineer in the agricultural engineering department at Alabama Polytechnic Institute and Alabama Agricultural Experiment Station. His work is with the latter, in the field of supplemental irrigation. He was recently a graduate at Virginia Polytechnic Institute.

Claud B. Williams is at Anchorage, Alaska, as a design engineer in hydraulics in the district office of the U.S. Army Corps of Engineers. He was previously engaged in engineering practice in California.

Merle L. Esmay, who has been an assistant professor on the agricultural engineering staff at Iowa State College since 1947, and who recently completed graduate work for a Ph.D. at Iowa State under Professor Henry Giese, specializing in farm buildings, has resigned to accept a position on the agricultural engineering staff at the University of Missouri with the rank of full professor. He will head the farming buildings work on the resident staff and will be concerned with both teaching and research.

John J. Devine, formerly employed in the experimental department of Massey-Harris Co., Ltd., in Scotland, has for the past six months been employed by the experimental department of the John Deere Plow Co., at Welland, Ontario, Canada.

"RUBBER RIVETS"

Exclusive in Manhattan Endless Belts

ELIMINATE SPLICE FAILURES

You get much longer life out of Manhattan's Endless Flat Belts because of our exclusive use of "Rubber Rivets" in splicing the cover. In ordinary endless belts the stress of flexing over small pulleys concentrates where the cover is spliced. Failures of these belts start at this point of greatest weakness • With Manhattan Belts the stress is dissipated over a wide area. The difference is illustrated above. During manufacture "Rubber Rivets" are inserted at pre-determined points through the cover. Vulcanizing then makes these rivets an integral part of the belt, eliminating possibility of separating • This is the "Extensible-Tip" exclusive with Manhattan. This plus feature in all Manhattan Endless Belts gives you longer belt life and lower belt cost . . . typical of the R/M engineering that also saves you money in hose, V-belts and conveyor belts •

R/M

MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

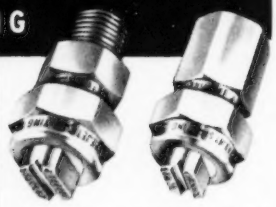
RAYBESTOS-MANHATTAN, INC.

Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Packings • Brake Linings • Brake Blocks, Clutch Facings • Asbestos Textiles • Sintered Metal Parts • Bowling Balls

SPRAY NOZZLES FOR BETTER, FASTER FARM SPRAYING

TEEJET performance features

- Super precision orifice tips . . . DRILLED and MILLED for uniform spray and exact volume control.
- Interchangeable orifice tips . . . in every type and capacity from one gallon per hour and up.
- Eleven different spray angles from 0° (solid stream) to 150°.
- Unconditionally guaranteed for performance as specified.
- Factory inspection and test of all nozzles and tips before shipment.



The investment a farmer makes in chemicals, equipment and time will dependably produce a profit when TeeJet Spray Nozzles are installed on the spray boom. TeeJet nozzles are precision made to provide the best in performance from both equipment and chemicals. Proved by test in every type of farm spraying. For complete information, write for Bulletin 58 . . . the comprehensive reference manual for farm spray nozzles, strainers and fittings.

SPRAYING SYSTEMS CO.
3228 RANDOLPH ST. • BELLWOOD, ILLINOIS
Write for Bulletin 58

SPRAYING SYSTEMS TeeJet SPRAY NOZZLES

Farm Machinery Designers

Graduate Engineers, Mechanical or Agricultural, with farm machinery background, that are interested in the design and development of Harvesting equipment.

Openings in an expanding Engineering Department for all grades including recent graduates or those with years of experience. Opportunity for advancement for those who wish to join a progressive organization.

Ideal Engineering facilities, located in a small city in the Midwest.

Salaries commensurable with education, experience, and background.

Address box number NI-52, c/o Agricultural Engineering, St. Joseph, Michigan.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated:

POSITIONS OPEN: 1951 — AUGUST—0-420-433; SEPTEMBER—0-455-442; OCTOBER—0-401-411; DECEMBER—0-457-547, 450-549, 473-550, 480-551. 1952 — JANUARY—0-494-552, 484-553, 492-554; FEBRUARY—0-503-556, 502-557.

POSITIONS WANTED: 1951 — MAY—W-253-51, 276-56; JUNE—W-232-60; SEPTEMBER—W-331-72, 334-74; OCTOBER—W-383-76, 391-78; DECEMBER—W-459-81, 464-82, 461-83, 454-84, 467-85, 477-89. 1952 — JANUARY—W-485-90, 488-91; FEBRUARY—0-504-92, 487-93, 528-95, 529-96.

NEW POSITIONS OPEN

SALES MANAGER to take complete charge of sales and advertising for a manufacturer of sprayers, dusters, pumps, etc., in New York State. Graduate agricultural engineer with experience in implement sales, and some knowledge of the sprayer industry. Must be ambitious and capable of rebuilding a complete sales organization including implement distributors and dealers. Considerable opportunity for well-qualified man. Age 35-45. Salary open. 0-537-558

SALES SERVICE ENGINEER for sales-development liaison work with a manufacturers' tire development division. Requires contact work with farm tractor and equipment manufacturers and travel 50 per cent of time. Initial training 6 mo at main office and plant, followed by permanent station in Chicago area. BS deg in agricultural engineering or equivalent. Experience in development, manufacture and application of farm equipment desirable. Appearance, personality, and other qualifications for personal contact work must be excellent. Good opportunity for advancement. Opening to be filled as soon as possible. Age 25-35. Salary $4000 min. 0-548-559

FIELD REPRESENTATIVE for educational and promotional work primarily in farm structures field, with trade association. Includes work with colleges, extension specialists, 4-H Clubs, vocational agriculture leaders, farm managers, farm and distributor exhibits. Farm background and BS deg in agriculture, preferably in farm structures field. Experience in farm sales and promotional work desirable. Usual personal qualifications for contact work. Considerable travel necessary. Good opportunity for advancement. Age 25-35. Salary $3600-4200 range to start. 0-552-560

FARM EQUIPMENT ENGINEERS (various grades): detailers, draftsmen, assistant project engineer, senior field test engineer, for design, development and test work with manufacturer of broad line of tractors and operated equipment. Location Midwest. BS deg in agricultural engineering, or equivalent. Above average in intelligence and personal characteristics. Alert and aggressive recent graduates in agricultural or mechanical engineering will qualify for detailers. Similar training and some years of successful experience in farm equipment engineering desired for other positions. Excellent opportunity for maximum creative work and utilization of individual talents. Salary open. 0-559-561

SUPERVISOR OF EXPORT PRODUCT EDUCATION to conduct training courses in the Spanish language on the use of agricultural tractors and farm machinery in Central and South American countries for a major manufacturer of farm equipment. Must be willing to travel 50 per cent of the time. Other 50 per cent would be spent at the company's office and plant in the Midwest. BS deg in agricultural engineering, or equivalent. Supervisory ability and experience in the compilation and preparation of technical information on farm equipment desirable. Must be able to read, write, and speak Spanish fluently. American born, with above average intelligence and ability to get along well with others. Excellent opportunity for qualified man. Age 30-40. Salary open. 0-576-562

AGRICULTURAL SPECIALISTS FOR NEAR EAST AND SOUTHERN ASIA. A large number of specialists in certain agricultural fields are needed to represent the United States in technical cooperation programs abroad, especially in the Near East and Southern Asia, according to a recent announcement by the U.S. Department of Agriculture. The greatest needs are for extension and agricultural education specialists. There also are a number of positions for specialists in agricultural engineering, soils and agronomy.

About 500 United States agricultural technicians now are doing technical cooperation work abroad, under programs of this government and the United Nations. The USDA Office of Personnel has developed a national roster of professional agriculturists that is being used by the Department and other agencies in recruiting such personnel. Specialists have been recruited rapidly enough to fill most current staff needs for some geographic areas and in certain subject matter fields. However, expanding program requirements in the Near East and Asia now make it necessary to enlarge the roster of qualified applicants.

This country's technical cooperation programs, which include Point Four, require professionally trained people of proven ability. These employees must have had several years of successful professional experience and must be skilled in their professions. They must have leadership ability, maturity of judgement, and the personal qualities required of foreign representatives of the United States Government.

Applicants are not required to take Civil Service examinations. However applicants must meet high qualification standards established for

(Continued on page 180)

Where It's Needed Most

Now A Waterproof Structural Glue

IN BARNS... The best roof in the world can't keep a barn dry inside. One cow, for example, gives off more than a gallon of moisture as vapor every day at 55 degrees. But the cows could be swimming and the moisture would not weaken the glue in Rilco rafters. They're bonded into one piece—PERMANENTLY—with resorcinol glue.

Look for "Exterior" or "Ext." The sign of waterproof lamination.

IN UTILITY BUILDINGS... Versatile Rilco Utility buildings not only serve as a machine shed, but are easily adaptable for use as efficient dairy or feeding barns, crop storage, poultry and hog houses. Here again, it's important that the glue be completely waterproof. Resorcinol glue, developed for shipbuilders during the war, protects Rilco framing from sill to ridge at no extra cost.

Engineered construction makes RILCO buildings stronger 3 ways

- **1. KILN-DRIED DOUGLAS FIR,** laminated by Rilco, makes framing members 4 times as strong as nailed rafters. Available for every width and type of building.
- **2. WATERPROOF RESORCINOL GLUE** stands up indefinitely under any moisture conditions. Permanent bonding means enduring strength.
- **3. ENGINEERED CONNECTORS** at the key points—sill, floor joists and roof ridge—make a continuous framing member with maximum wind resistance.

RILCO *Laminated* **PRODUCTS, INC.**

Meet Mr. Stickney, the man in charge of glue at Rilco. Send the coupon.

RILCO *Laminated* **PRODUCTS, INC.**
2506 First Nat'l Bank Bldg., St. Paul 1, Minn.

- Please send me the new Glue booklet

Name

Address

City Zone State

SISALATION WATERPROOF SISAL REINFORCED REFLECTIVE INSULATION

Farmers have proved SISALKRAFT provides dependable protection

For over 20 years many uses of SISALKRAFT Products on the farm have proved this tough, waterproof protective paper is worthy of your highest endorsement. Write for complete information on ALL farm uses of SISALKRAFT and SISALATION.

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the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong". Wear it.

STYLES AND PRICES OF ASAE EMBLEMS

With blue ground for Fellows, Members, and Associate Members — furnished either in pin with safety clasp or lapel button — $3.50 each.

With red ground for Affiliates — furnished only in pin with safety clasp — $3.50 each.

Send orders to ASAE, St. Joseph, Michigan.

PROFESSIONAL DIRECTORY

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 40 cents per line to ASAE members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

Personnel Service Bulletin

(Continued from page 178)

these positions. Candidates preferably should be between 30 and 60 years old. Salary rates range from $5,913 to $11,130 a year. In addition, employees may receive quarters and living allowances, and in some cases post differential allowances of from 10 to 25 per cent of the base salary.

Interested persons who are qualified by training and by several years of responsible professional experience in agriculture are asked to submit Form 57. Application for Federal Employment, or write to the Office of Personnel, U.S. Department of Agriculture, Washington 25, D.C. Form 57 may be obtained from first and second-class post offices.

NEW POSITIONS WANTED

EXTENSION, teaching or research in soil and water field in public service or with manufacturer preferably east of Mississippi River. Willing to travel. BS deg in agricultural engineering, 1948, North Carolina State College. Experience 3 yr as agricultural engineer in SCS. Traffic clerk 4 yr. Sales work 2 yr. War enlisted and commissioned service 5 yr, anti-aircraft. Married. Age 33. No disability. Available on reasonable notice. Salary $4200. W-514-97

DESIGN, development, or research in power and machinery field with industry. Prefer western U.S.A. BS deg in agricultural engineering, 1949, Mississippi State College. Dairy farm experience, including managerial duties, 3 yr. Operating wood preserving plant, one year. Veterans on-farm-training instructor in maintenance or farm equipment, planning and construction of farm buildings, and use and care of shop tools, 3 yr. During same period gained experience in surveying for State Board of Education. War enlisted service in Signal Corps. Married. Age 28. No disability. Available now. Salary $3600-4200. W-525-99

EXTENSION, teaching, or research in rural electrification with industry or public service in U.S.A., U.S. possessions, or Latin America. BS deg in agriculture, major in agricultural engineering, 1949, Michigan State College. Michigan farm background. Air Corps and Air Force noncommissioned service 8 yr with duty on aircraft radio and electrical repair. Edited monthly newsletter for REA Cooperative one year. Currently power use adviser (educational and promotional work) for an REA Cooperative. Married. Age 32. No disability. Available on reasonable notice. Salary open. W-538-100

EXTENSION, teaching, research, or management in power and machinery or farm structures field, with college or farming operation, preferably in northern California (for family health reasons). Studied aeronautical engineering 2 yr. BS deg in agriculture, 1951, Cornell University. Farm background. Managed home farm and farm labor. Additional experience in carpentry, part time in college and two summers. Taught farm mechanics and farm power and machinery part time 4 terms in college. War service as a naval aviation cadet and commissioned pilot. Commercial pilot one year. Married. Age 27. No disability. Available now. Salary $4800. W-540-101

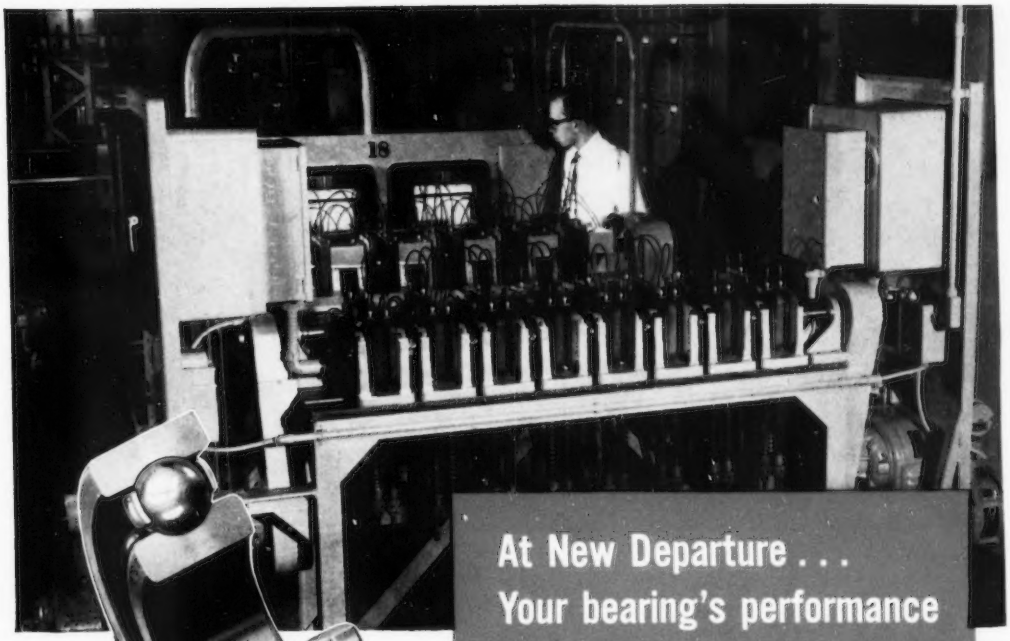
EXTENSION, teaching, service, or management in rural electric or soil and water field, in public service, anywhere in U.S.A. BS deg in agricultural engineering 1949, University of Minnesota. War noncommissioned service in Air Force over 3 yr. Agricultural engineer over 2 yr, in soil conservation and irrigation with Office of Indian Affairs. Married. Age 30. No disability. Available on 4 weeks notice. Salary $5400. W-542-102

DESIGN, development, research, or writing, in power and machinery or rural electric field, with manufacturer or federal agency, preferably in Midwest. Prefer little or no travel. BS deg in agricultural engineering, 1949, Michigan State College. Dairy farm background. War enlisted and commissioned service (navigator) in Air Corps, 2½ yr. Over 2 yr in present position as research engineer on field problems with manufacturer of dairy product processing equipment. Married. Age 31. No disability. Available on 30 days notice. Salary open. W-560-103

RESEARCH, teaching, design, or development in farm structures with industry or public service, anywhere in U.S.A. BS and MS deg in agricultural engineering, 1947 and '48, Iowa State College. One year in research on roofing. Teaching and research one year. Veterans on-farm-training instructor 2 yr. War enlisted service 3 yr. Married. Age 34. No disability. Available July 1. Salary $5000. W-566-104

DESIGN, development, or research in farm structures or soil and water field, in industry, preferably in East. BS deg in agricultural engineering expected in June, University of Massachusetts. Junior agricultural engineer full time one summer, part time current school year, with consulting service. Single. Age 21. No disability. Available June 16. Salary open. W-573-105.

SALES or service in power and machinery or farm structures field with manufacturer anywhere in U.S.A. BS deg in agricultural engineering, 1941, University of Georgia. Experience as sales engineer, construction machinery field, 2½ yr; instructor in machine shop, 8 mo; general supervision of residential construction for contractor, 8 mo. War commissioned service as diesel engineer with Navy 4½ yr, Army Signal Corps 8 mo. Recall to active duty in Navy March to July 1951. Single. Age 35. No disability. Available May 1. Salary open. W-564-106



At New Departure . . . Your bearing's performance is tested and proved *before* you use it

Considering the big part ball bearings must play in the efficient operation of your machine, it is important for you to *know*, and in *advance*, how the bearings will perform.

For example, you need to know what results may be expected from each type of grease under varying conditions.

Supplying you with this information is just one of the functions of New Department's new and ultra-modern engineering laboratory.

To help you get the answers:

What is the determining factor of seal-bearing life?

How operating conditions contribute to metal fatigue?

Which has the most effect on grease life—speed or load?

Lubrication selection.

. . . a monograph, "Grease Lubrication of Ball Bearings," by New Departure's Manager of Research, Development and Design, will be mailed upon request.

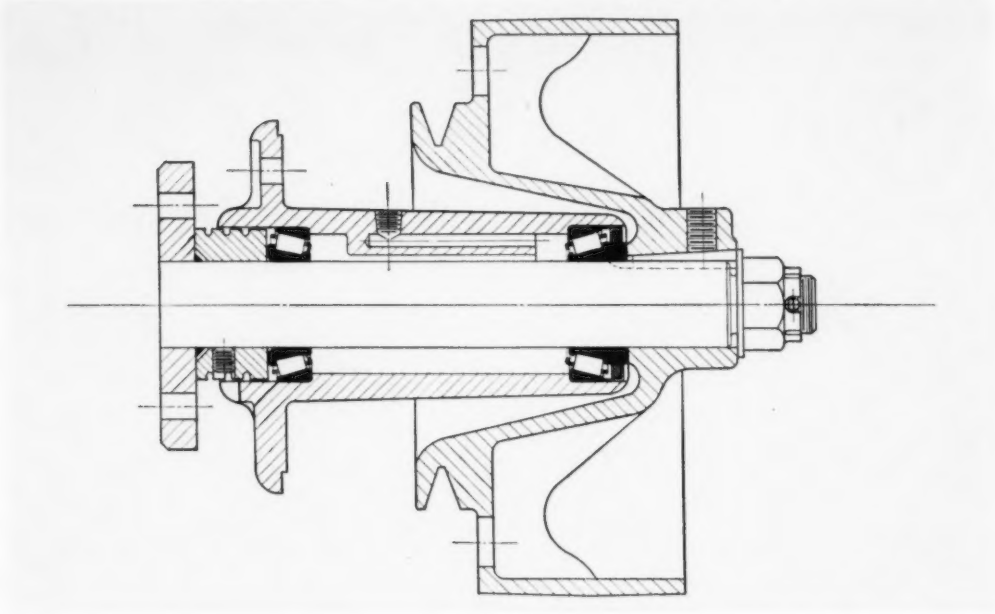
163C

Nothing Rolls Like a Ball . . .

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS
BRISTOL, CONNECTICUT

EVERY NEW FARM TRACTOR HAS TIMKEN BEARINGS; MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!



TIMKEN® bearings improve performance of Rosenthal corn husker-shredder

ENGINEERS of the Rosenthal Corn Husker Company improved the performance of their corn husker-shredder by mounting the blower shaft and other vital parts on Timken® tapered roller bearings.

In this mounting, a flange is welded to the straight shaft which provides backing for the annular grooved closure and the inner Timken bearing. A felt closure contacts the extended rib of the outer Timken cone. These closures retain the lubricant within the housing. Dust and moisture are kept out and lubricant kept in. Timken bearings, likewise, permit a rigid assembly, holding shafts and gears in alignment, eliminating deflection, saving power and reducing wear.

Timken bearings provide high load-carrying capacity by reason of the line contact between the rollers and races. As a result, smaller bearings can be used, often saving space. The tapered construction enables them to take both radial and thrust loads in any combination so that separate thrust bearings or washers are not needed.

Write for your copy of "Tapered Roller Bearing Practice On Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design →

Tapered Roller TIMKEN BEARING EQUIPPED

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST ◫ LOADS OR ANY COMBINATION ✳